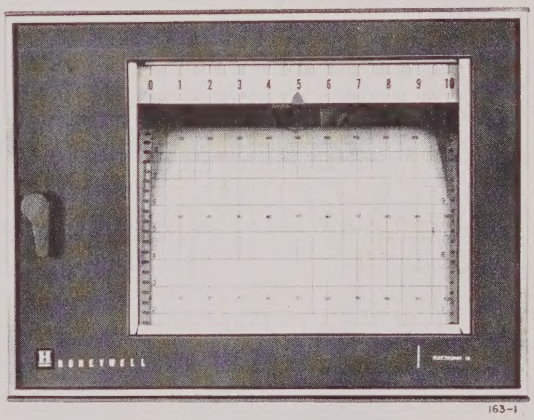
HONEYWELL

INSTRUCTIONS

719433

Instruction Manual
*ElectroniK 16**
Strip Chart Recorder



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NUMBER 011-46 ISSUE 1

HONEYWELL - Industrial Products Group Wayne and Windrim Aves., Phila.44, Pa.

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* *Tradename - HONEYWELL INC.*

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NOTE: Your instrument can have either of two models of the Constant Voltage Circuit. To insure that you have the proper information, we are enclosing instructions for both.

To distinguish which are you have, observe the sketch of each given in the description portion of the instructions (134-19 and 134-21). Under the cover of your Constant Voltage Circuit, you will notice the presence of a transformer if you have number 1. The transformer is not located on the circuit board if you have number 2.

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INSTRUMENT **DESCRIPTION**

1. GENERAL

a. The ElectroniK 16* Strip Chart Recorder is a continuous balance servo potentiometer. Used in conjunction with many types of primary elements, it automatically measures the magnitude of a variable by comparing the input signal from the primary element with a feedback signal from the measuring circuit; it responds to input changes by rebalancing. The measured variable's value is recorded on calibrated 11-inch strip chart paper which is automatically rerolled to provide a permanent record.

b. The instrument's physical and design characteristics meet or exceed those specified in ASA #39.4-1956. Its compatibility with a variety of primary elements and its many optional features make the instrument flexible for use in laboratory applications.

2. SPECIFICATIONS

a. To assure optimum performance, we recommend maintaining supply voltages between 107 and 127 volts ac. The instrument will function even if supply voltages reach extremes of 100 or 130 volts ac.

b. Instruments designed for a nominal frequency of 60 cps will accept variations from 58 to 62 cps; they will tolerate extremes of 56 or 64 cps. Variations from a 50 cps nominal frequency should be within 48 to 52 cps (46 or 54 cps extreme).

c. Recommended ambient temperature limits at the instrument location are 59 to 105° F; however, extreme temperatures of 15 or 125° F can be tolerated.

d. Calibrated accuracy for all millivolt spans is $\pm$ 0.25% of span; for compensated actuations it is $\pm$(0.25% of span + 1/4° C).

e. Standard instruments are designed for operation with source resistance from 0 to 10,000 ohms. (Higher limits are available).

f. Instrument deadband for any span will not exceed 0.1% of full scale span, under reference conditions.

g. Maximum suppression, available on standard instruments, is twice the instrument span. (Higher limits are available.)

h. Span step response time is the time required for the indicator carriage to travel from 0% to 100% full scale, and balance within the instrument's rated accuracy, in response to a step change in input voltage equal to the instrument span. The nominal span step response time rating is the maximum time required to achieve balance with normal mechanical loading of the servo system. Nominal response times available are 15, 5, and 1 seconds with 60 cps operation; 18, 6, and 1.2 seconds with 50 cps operation.

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CHASSIS DESCRIPTION

1. GENERAL

a. The instrument's die-cast aluminum chassis (figures 1 and 2) supports all the components of the display, and rebalancing system.

b. The chassis slides on channel tracks. All instrument components are easily accessible; you merely lift the chassis release latch, which is also a handle, 90° into the horizontal plane, and slide the entire chassis out of the enclosure. Stops allow the chassis to be extended partially (for operating maintenance) or fully (for service). To remove the chassis from the case, disconnect a single electrical plug connection and manually override the mechanical chassis stops.

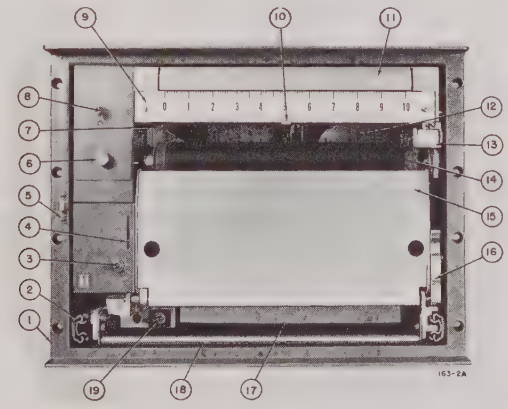

Figure 1. Instrument, door removed

LEGEND

1. Case
2. Channel track
3. Chart switch
4. Chart supply indicator (optional)
5. Door catch
6. Ink compartment
7. Ink delivery tube
8. Pen lifter (optional)
9. Scale
10. Indicator and recording carriage
11. Chassis dust cover
12. Drive cable drum
13. Event marker pen (optional)
14. Chart drum
15. Chart tearoff groove
16. Chart housing release latch
17. Servo circuit unit
18. Chassis release latch
19. Power switch

2. SYSTEMS

a. The servo system includes all the components that translate the error signal into an indication of the value of the process variable; these include:

.... the balancing motor, which develops the torque to reposition the measuring slidewire and the indicator carriage,

.... the drive cable, which translates the rotary motion of the motor to a lateral motion of the indicator carriage,

.... the indicator and recording carriage, which indicates the variable's magnitude on the calibrated scale while the print mechanism records that value on the chart,

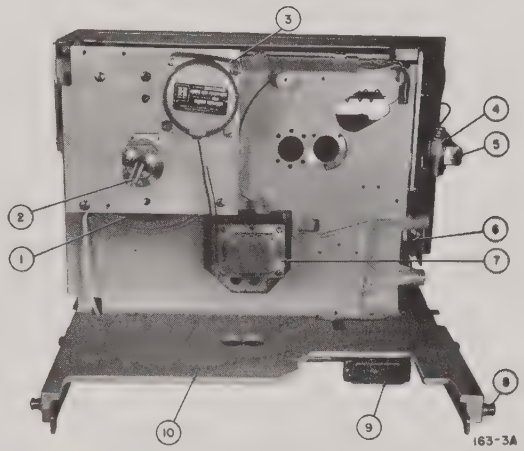

Figure 2. Instrument Chassis, removed from case

LEGEND

1. Drive gear
2. Servo drive shaft
3. Balance motor
4. Ink reservoir (optional event marker pen)
5. Ink compartment
6. Chart drive motor
7. Power transformer (amplifier)
8. Guide bearing
9. Connector
10. Instrument chassis

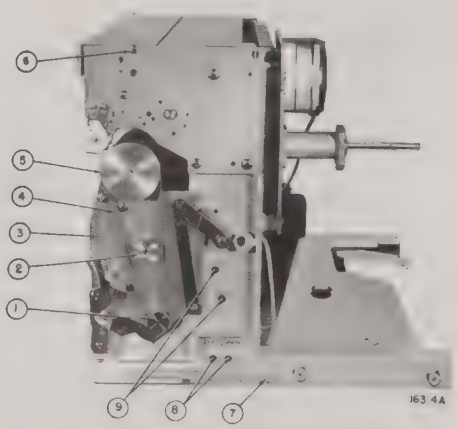

Figure 3. Instrument Chassis, right-hand view

LEGEND

1. Chart reroll knob
2. Chart supply knob
3. Chart carriage
4. Reroll drive spring
5. Chart advance knob
6. Dust cover retaining screw
7. Chassis stop
8. Adjustors (measuring circuit)
9. Adjustors (amplifier)

.... the amplifier circuit, which converts the d-c error signal into an a-c signal and amplifies that signal to drive the balancing motor.

b. The display system includes recording and indicating components such as: chart, chart carriage, indicator carriage, recording device, calibrated scale, and the chart drive and reroll system (figure 3). A variety of optional features are available, including the chart supply indicator shown in the illustrations. Procedures for installing the chart and for placing the recording device in operation, are included later in this manual. The remote ink reservoirs are located on the left-hand side of the chassis in a pull-out drawer-type compartment (figure 4).

LEGEND

1. Ink delivery tubes
2. Pen lifter mechanism
3. Chart drive mechanism
4. Ink reservoir (recording pen)

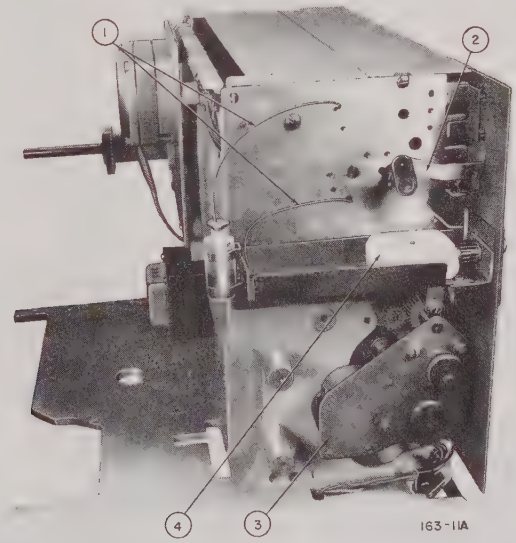

Figure 4. Instrument Chassis, left-hand view

3. AUXILIARY SWITCHES

a. Auxiliary MICRO SWITCH* units for alarm or signalling can be supplied as an optional feature on this instrument; they mount on the rear of the chassis assembly and are adjusted from the back of the chassis (backset design).

b. Auxiliary switches are illustrated in a separate section which is included (later in this manual) when this equipment is supplied.

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4. SERVO CIRCUIT UNIT

The servo circuit unit (figure 5) is mounted to, but insulated from, the instrument chassis. The unit consists of printed circuit panels for the amplifier, measuring circuit, and constant voltage circuit. These are completely enclosed by a housing and cover plate which are part of the Faraday shield used to overcome common mode stray noise.

CAUTION: The servo circuit unit may be at a relatively high potential, (dependent on operating conditions), since the input potential and common mode stray potential are both present on the instrument shield. Refer to the discussion of shield connections in the installation procedures before touching or attempting to remove the cover plate of the servo circuit unit.

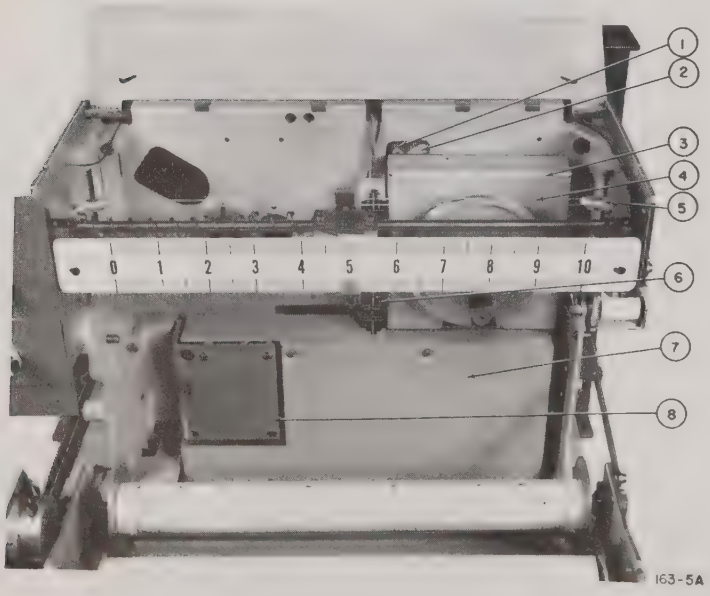


Figure 5. Servo components

LEGEND

1. Servo motor pinion
2. Drive gear
3. Slidewire cover
4. Drive cable
5. Guide Pulleys
6. Terminal block (amp.-mtr.)
7. Servo circuit unit
8. Power transistor heat sink

ENCLOSURE DESCRIPTION

1. CASE

a. The instrument is housed in a dust and moisture-resistant steel case suitable for relay rack, panel, or bench mounting. External dimensions of the case are specified on a separate diagram included in this manual.

b. The exterior finish will resist normal industrial atmospheres. Steel channel tracks, which support the chassis and permit its removal, are mounted to the sides of the case.

c. All connections, including those for power and primary elements are made externally (from the back) to the terminal panel (figure 1) via knockouts in the case. The input panel also includes the compensation block for the thermocouple reference junction (when applicable). A metal cover protects all connections when the instrument is in service.

2. DOOR

a. You can quickly remove the door to expedite servicing, by merely lifting the release latch located in the door assembly at the upper hinge pivot.

b. The door assembly includes the hinge pivots, door glass, gaskets, masking strips, door latch and (optional) integral lock assembly.

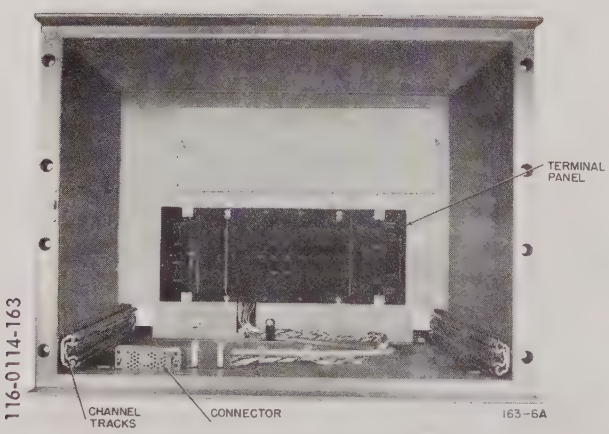


Figure 1. Case interior.

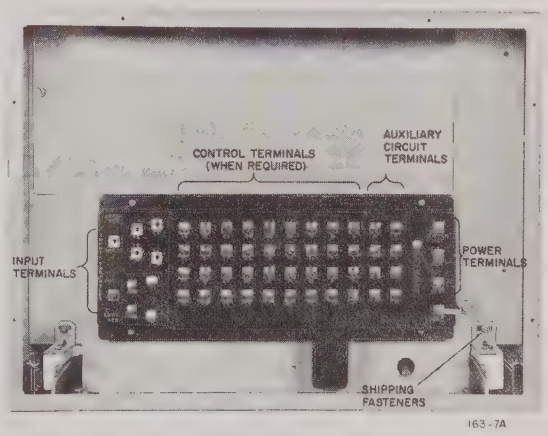


Figure 2. Terminal compartment.

MEASURING CIRCUIT — DESCRIPTION

1. GENERAL

a. A printed circuit board type measuring circuit is supplied in this instrument. The range card can be easily removed and replaced by another card to provide the required range and actuation.

b. Since easy and convenient conversion is a basic feature of this design, all standard measuring circuits are covered in this section.

c. The range card, housed in the servo circuit unit on the instrument chassis, includes most measuring circuit components. For thermocouple actuations, a reference junction compensation block is mounted on the input terminal panel. Clearly identified terminals are provided for connections from the input terminal panel, from the constant voltage circuit, and to the rebalancing element.

d. Electrical span and zero adjustors are mounted on the range card: each can be adjusted via access holes provided in the side of the instrument chassis. Both adjustors have a 100-turn full scale adjustment which is equivalent to a 40% full scale span adjustment and 60% full scale zero adjustment.

e. The measuring circuit uses precision manganin range resistors wound on plastic spools, and mounted directly to the range card. Composition type resistors are used in non-critical locations (the optional burnout resistors).

2. CIRCUIT

a. The measuring circuits, are variations of the standard potentiometric circuit.

b. The physical appearance of the measuring circuit will vary, depending on the circuit configuration, for each instrument range and actuation. The basic circuit is modified as necessary to provide all actuations. Each available circuit is described and shown schematically in the Theory section for the measuring circuit.

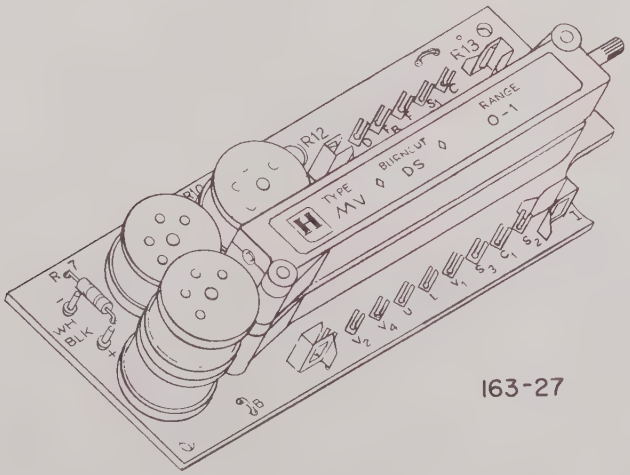


Figure 1. Typical Range Card

CONSTANT VOLTAGE CIRCUIT

DESCRIPTION

1. PURPOSE AND USE

The constant voltage circuit develops and maintains a stable output voltage across the measuring circuit's resistive load, and causes a steady current to flow through that circuit. Current distribution within the measuring circuit is determined by the resistance ratios of the circuit branches. A stable current passing through the calibrated slidewire is necessary to maintain the rated accuracy of instrument measurements.

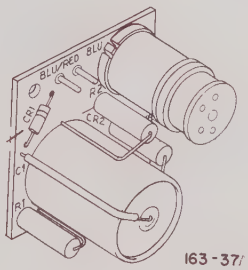


Figure 1. Constant voltage circuit.

2. CONSTRUCTION

The constant voltage circuit is packaged on a 2-inch square printed circuit panel; the complete assembly is approximately 1-1/2 inches high. Electrical connections from the power assembly and the measuring circuit panel are made via pins; conductor colors are clearly marked on the panel.

3. PERFORMANCE

a. The constant voltage circuit is a precision d-c power supply. It uses a diode rectifier and filter circuit to convert ac from the power transformer to the dc required by the measuring circuit. This is followed by cascaded zener diode voltage regulation stages which provide high output stability regardless of input voltage variations; high stability, regardless of ambient temperature variations, is maintained by a copper resistor included in the output circuit to compensate for the temperature coefficient of the second stage zener diode.

b. With the constant voltage circuit connected to a constant resistive load, the output voltage will be virtually unaffected by variations in either line voltage or ambient temperature.

c. The output may be opened or shorted without causing any damage to the device.

4. ACCURACY

a. With any combination of a +10 to -20 volt variation, from a 120 volt supply, and a ±55° F variation, from a reference temperature of 85° F, the output voltage will remain constant within ±0.15%.

b. The output voltage will remain within ±0.03% if the 120 volt supply changes by ±10 volts; within ±0.04% for a -20 volt variation.

c. Calibrated accuracy of the output voltage under reference conditions of 85° F and 120 volts ac is ±0.08%.

NOTE: When the constant voltage circuit is not in use, storage temperatures between -60° F and +160° F can be tolerated without damage to the unit.

CONSTANT VOLTAGE CIRCUIT — DESCRIPTION

1. PURPOSE AND USE

The constant voltage circuit develops and maintains a stable output voltage across the measuring circuit, and causes a steady current to flow through that circuit. Current distribution within the measuring circuit is determined by the resistance ratios of the circuit branches. A stable current passing through the calibrated slidewire is necessary to maintain the rated accuracy of instrument measurements.

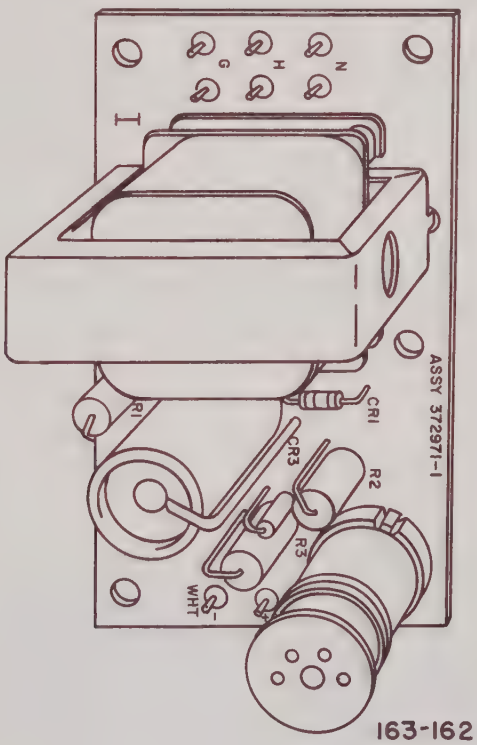


Figure 1. Constant Voltage Circuit.

2. PERFORMANCE

a. The constant voltage circuit is a precision d-c power supply. It uses a diode rectifier and filter circuit to convert ac from the power transformer to the dc required by the measuring circuit. This is followed by cascaded zener diode voltage regulation stages which provide high output voltage stability with line voltage variations. A copper resistor in the output circuit compensate for the temperature coefficient of the second stage zener diode, providing high output stability with ambient temperature variations.

b. With the constant voltage circuit connected to a constant resistive load, the output voltage will be virtually unaffected by variations in either line voltage or ambient temperature within the stated limits.

c. The output can be opened or shorted without causing any damage to the device.

3. ACCURACY

a. With any combination of a +10 to -20 volt variation, from a 120 volt supply, and a ±55°F variation, from a reference temperature of 85°F, the output voltage with rated resistive load will remain constant within ±0.15%

b. The output voltage will remain within ±0.03% if the 120 volt supply changes by ±10 volts; within ±0.04% for a -20 volt variation.

c. Calibrated accuracy of the output voltage with rated resistive load and under reference conditions of 85°F and 120 volts ac is ±0.08%.

NOTE: When the constant voltage circuit is not in use, storage temperatures between -60°F and +160°F can be tolerated without damage to the unit.

FOUR-SPEED CHART DRIVE

DESCRIPTION

1. GENERAL

A synchronous motor drives the chart drum through a four-speed gear train (figure 1). A shifting knob on the front panel permits selection of chart speeds of twice (2X), four times (4X), or eight times (8X) the basic speed; the chart drive operates at the basic speed in the 1X position. Speed changing is done through a purely mechanical shifting arrangement while the chart drive mechanism is moving.

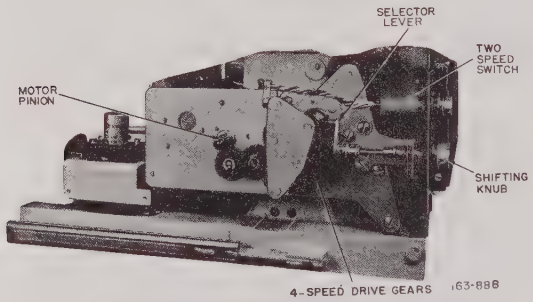
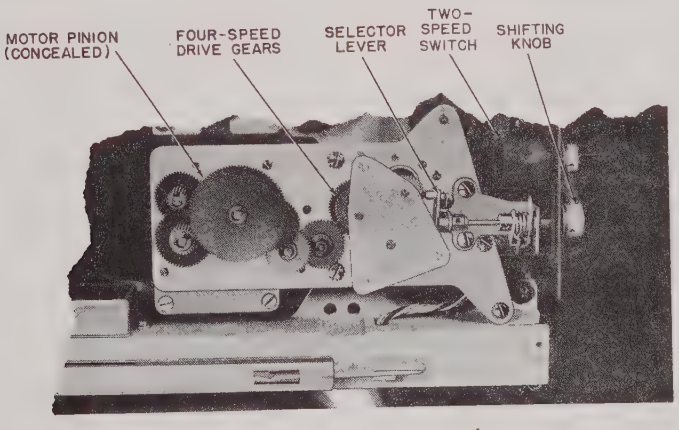
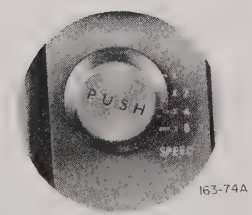


Figure 1. Four-speed chart drive mechanism.
a. One inch per minute basic rate or faster.



b. Thirty inches per hour basic rate or slower.



c. Shifting knob (on front panel).

2. OPERATION

a. With chart drive motor operating, press the knob in toward the chassis to engage the shifting mechanism.

CAUTION: Do not attempt to rotate the knob until it is pushed in as far as it will go.

b. Turn the knob to the desired multiplying factor.

c. Release the knob. There may be a slight delay while the gears mesh, but it is not necessary to hold the knob. A spring-loaded detent holds the knob at the new setting.

NOTE: The instrument can be equipped with an electrically operated two-speed drive in addition to the four-speed drive, to provide a total of eight chart speeds. When the two-speed unit is installed, it is described in a separate instruction section.

3. REPLACING MOTOR

a. Disconnect motor leads.

b. Remove the two nuts, two screws, and two lockwashers that mount the motor, and remove the motor. Mention the part number (on motor nameplate) when ordering a replacement motor.

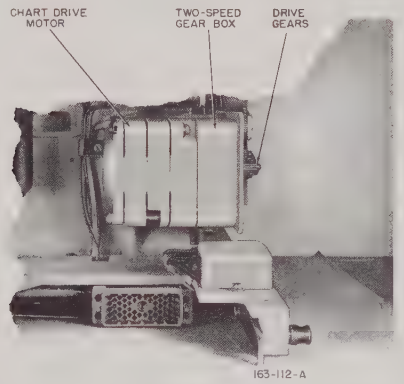
c. Mount the new motor with the screws, lockwashers, and nuts provided.

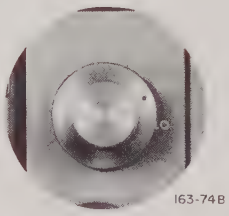
d. Refer to the wiring diagram when connecting motor leads.

TWO-SPEED GEAR REDUCTION UNIT — DESCRIPTION

1. GENERAL

a. The two-speed chart drive (figure 1) is a gear reduction unit installed between the drive motor pinion and the first gear of the drive train. The two-speed unit can be used with a single-speed gear train using the large high-torque motor or with the four-speed gear train. Features of the basic chart drive, such as speed-change gears in the single-speed unit or the manual speed changer of the four-speed drive are unaffected.





†Figure 1. Rear of chassis, showing two-speed gear box (insert shows switch on front panel).

b. Speed reduction ratios of 2:1, 3-1/3:1, 6:1, 10:1, 30:1, and 60:1 are available. Gear boxes are interchangeable and can be installed in the field by removing the chart drive motor, bolting the gear box in place, and re-installing the drive motor.

c. Chart speed is electrically controlled by a three-position switch on the front of the chassis (see insert, figure 1). The OFF position turns off the chart drive motor; HI is the basic chart speed; the LO position reduces chart speed to one of the ratios in paragraph b. Change gears on the single-speed chart drive can be used to double or halve either of the speeds produced by the two-speed drive. The selector of the four-speed drive can be used to multiply either the HI or the LO output of the two-speed unit by one, two, four, or eight, producing a total of eight different speeds.

2. OPERATION

a. The two-speed drive unit has two gear trains, a single gear between the motor pinion and the gear box output pinion, producing the basic or HI speed, and a train of two gears (2:1, 3-1/3:1, or 6:1 reduction) or four gears (10:1, 30:1, or 60:1) for the LO speed (figure 2). Both sets of gears are in constant mesh with the chart drive motor pinion and the gear box output pinion, which drives the first gear of the chart drive mechanism. Only one set of gears can drive the output pinion at a time. Two overrunning clutches in the two-piece hub of the output pinion limit its rotation to one direction (clockwise) and permit the idle gear train to run free.

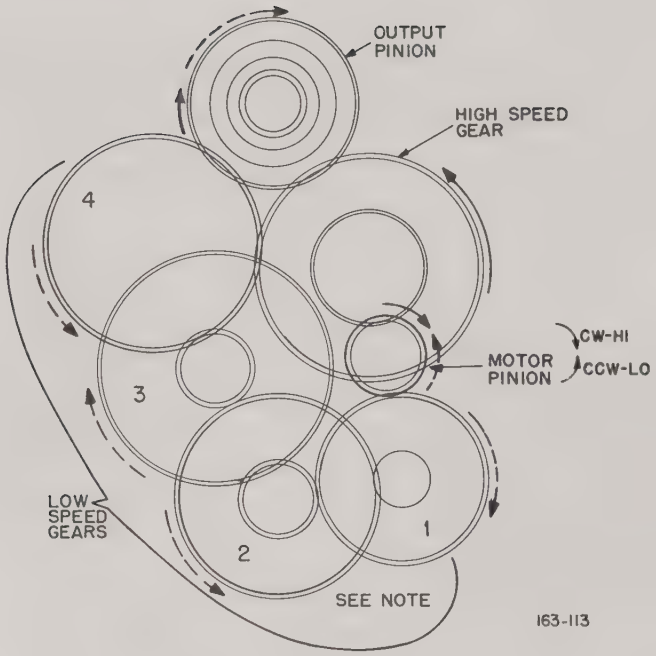


Figure 2. Two-speed chart drive mechanism.
NOTE: Configuration shown is for 10:1, 30:1, or 60:1 reduction. Gears 1 and 2 are not used on 2:1, 3-1/3:1, or 6:1 gear box; motor pinion meshes with gear 3.

b. When the motor pinion is turning clockwise, drive is through the single high-speed gear (solid arrows) driving the chart mechanism at its basic speed, while the clutch in the output hub permits the low-speed gears to free-wheel. When the chart motor is reversed electrically by the chart drive switch, phase-shifting current through its control winding, the motor pinion turns counterclockwise, operating the low-speed gear train (dashed arrows), while the high-speed gear free wheels. Note that the output pinion turns clockwise in both cases.

3. BASIC CHART DRIVE MECHANISM

a. When the two-speed drive is used with a single-speed mechanism, refer to the single-speed chart drive section for procedures such as changing speed-change gears and replacing the motor.

NOTE: The illustration in the single-speed section shows a high-speed drive (one inch per minute or faster). When a basic speed of 30 inches per hour or slower is required, additional gears are furnished.

b. When the two-speed gear box is used with a four-speed chart drive mechanism, refer to the instruction section on the four-speed drive for procedures associated with the motor and basic drive mechanism.

INSTRUMENT INSTALLATION

1. UNPACKING

a. The ElectroniK 16 Instrument is carefully packaged to protect it during shipment. Use reasonable care when removing the instrument from the protective container.

b. Place the shipping container on a flat surface preferably at bench height.

NOTE: It will be easier for the lifter and safer for the instrument if the inner carton is left on until the instrument is lifted into place.

c. Unseal the carton and remove the cardboard inserts and packing from the front of the instrument. Place the carton on its side, with the instrument in the upright position, and slide the instrument and packing out of the container. Remove the packing from the instrument, the heavy corrugated cardboard from the sides of the case, and the packaged accessory equipment.

d. A rolled strip chart is packaged separately, but included in the instrument shipping container.

e. If the instrument is supplied with the optional door lock, the key will be taped to the door glass. Turn the key clockwise to unlock the instrument, and rotate the door latch counterclockwise through 1/4-turn to unlatch the door. The door can then swing out 180° to the right.

2. LOCATION

a. Locate the instrument as close as practicable to the measured variable(s). The location should be clean and dry and have a relatively stable temperature. Ambient temperature should be within the range recommended under instrument design specifications.

b. Allow sufficient clearance at the front of the instrument to permit observation of the measurements as well as elbow room for performing periodic maintenance procedures and infrequent servicing procedures. Front clearance must also permit full extension and removal of the entire chassis assembly. Allow clearance at the rear of the instrument to permit access to all external connections.

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3. SHIPPING FASTENERS

Locate and remove the shipping fasteners as follows:

a. STANDARD SHIPMENT

(1) Remove back cover plate (figure 1) and two shipping brackets (figure 3) which secure chassis to case.

(2) Slide chassis out to first stop, then:

(a) On pen dragging instruments, remove tape which secures pen and untie ink drawer and manual pen lifter (if supplied). If remote pen lifter(s) is supplied, remove rubber grommet(s) in pen lifter solenoid yoke(s).

(b) On multirecord record instrument, untie print carriage rocker arm. On multirecord instruments with long (external) ink wheel, remove separately packaged ink wheel from shipping tube and remove rubber rings (do not remove Caplugs) on ends of ink wheel. Install ink wheel as described in Printing Mechanism Operation Section.

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Figure 1. Removal of back cover plate.

b. SPLIT SHIPMENT (Case and Chassis shipped separately)

(1) Case. Remove tape which secures connector plug and cable to case and remove tape from chassis slides. On multirecord instrument cases, unwrap and untie telescopic shaft.

(2) Chassis. Remove chassis from shipping board. Remove tape securing dust cover to side plate. Remove remaining shipping fasteners per paragraph a, above.

4. MOUNTING

a. Dimensions of the enclosure are given on the diagram included in this manual. The accessory kit supplied with the instrument contains hardware for panel or relay rack mounting; laboratory feet accessories are supplied when bench mounting is specified. A panel cutout template is supplied when panel mounting is specified.

b. Panel or relay rack mounting will be easier if you remove the chassis. When replacing the chassis, be sure to connect the electrical plug and, on multirecord instruments, also recouple selector switch telescope shaft.

NOTE: Shaft coupling is polarized. Rotate shaft until it seats properly and clamp closes in back of coupling.

c. If the instrument is mounted in a panel or relay rack, be sure to tighten all mounting bolts evenly to minimize strain on the instrument case.

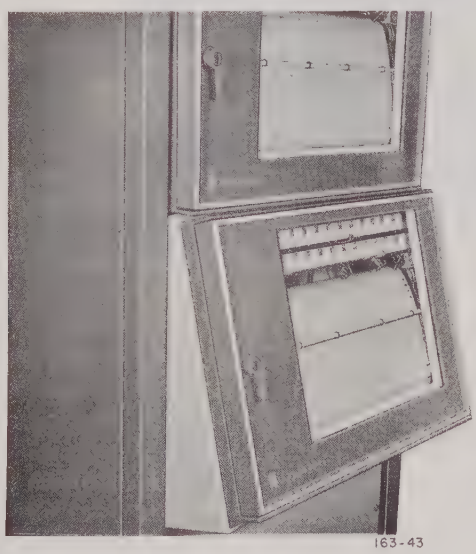

Figure 2. Instrument mounted -15° off normal.

d. While the instrument is commonly mounted in the vertical plane, it can be mounted up to ± 10° off vertical without affecting instrument performance; the instrument will still operate at extreme positions of + 15° and - 45° (figure 2). The optional adjustable ink supply is required for non-vertical mounting of pen dragging instruments.

5. ELECTRICAL CONNECTIONS

a. All electrical connections are made to the input terminal panel shown in figure 3.

b. A separate wiring diagram, included in this manual, shows the required external connections. While this wiring diagram is self explanatory, the following items deserve particular attention:

(1) Make all electrical connections to the terminals located on the back panel of the instrument. Each terminal is identified on the panel.

(2) Connect the instrument ground (GND) directly and separately to a known good ground, as recommended by the National Electrical Code. A cold water pipe is frequently an adequate ground; however, check the suitability of a particular water pipe before using it. If the pipe has a shallow location or uses fiber connectors, it may prove unsatisfactory. No. 14 B&S Gauge copper wire is recommended for the ground connection.

WARNING: Do not connect the instrument ground terminal to the neutral a-c line terminal.

Figure 3a. Input terminal panel, pen dragging instrument

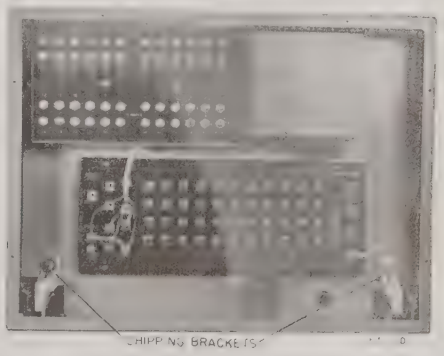

Figure 3b. Input terminal panel, multirecord instrument.

(3) Connect power leads as follows:

(a) Check the line to determine its neutral (grounded) side. (The neutral side of the line has the lower voltage between it and true ground.)

(b) Make connections to the HOT and NEUT. terminals on the panel assembly.

(c) Make electrical connections through knockout holes provided in the case. Knockouts are provided in the top, bottom and both sides of the terminal compartment for both 3/4 and 1" conduit connections. Select and open knockouts as required.

(d) If rigid conduit is used, make connections to the case with approximately 18 inches of flexible conduit to relieve strains on the instrument case.

(4) Install the primary element(s) and make connections as specified later in this manual.

(5) Replace cover plate on back of instrument.

6. OPTIONAL EQUIPMENT

Optional equipment may require additional electrical connections. If required, this information is included later in this manual.

SHIELD INSTALLATION

1. GENERAL

a. For satisfactory performance the instrument shield must be connected to either the plus (+) (V_1) or minus (-) (V_3) input terminal (figure 1). This arrangement places the shield at a potential equal to the sum of the stray voltage plus the input signal, and prevents common mode (longitudinal) stray currents from passing through the measuring circuit and amplifier to ground. Figure 1 shows the shield arrangement supplied with the instrument when shipped. The shield includes the servo circuit unit and cover plate, and rebalancing element housing. Figure 2 shows the undesirable situation which would result if the shield jumper were accidentally omitted. Note that stray currents could flow to ground through the effective leakage capacitances C1 and C2. (Only typical capacitance locations are shown).

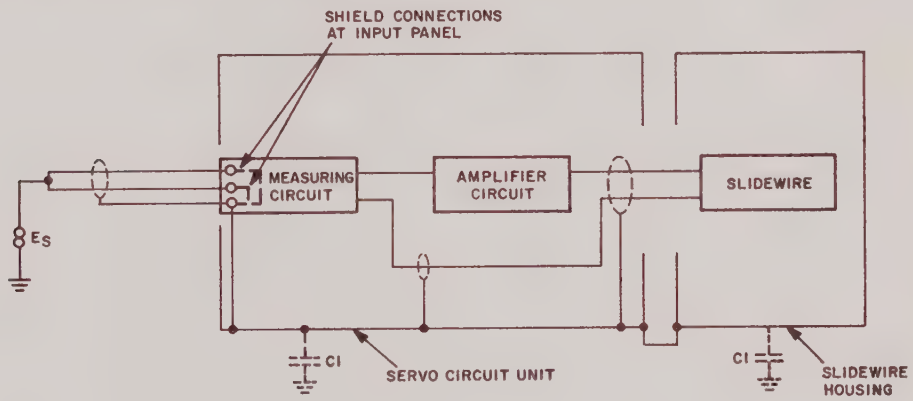

Figure 1. Instrument Shield

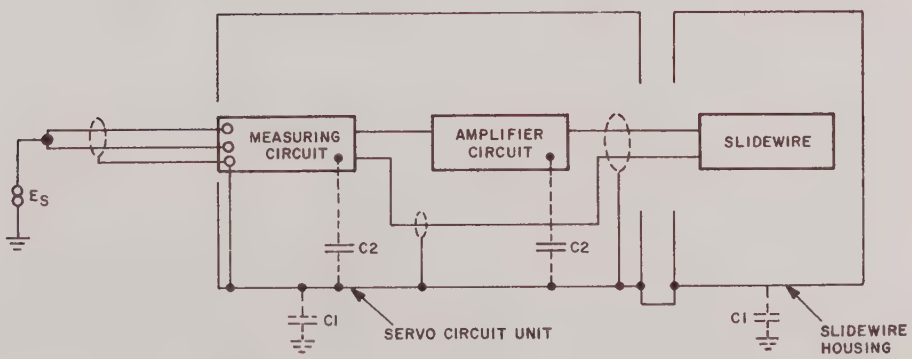

Figure 2. Effect of NOT Connecting Input to Shields

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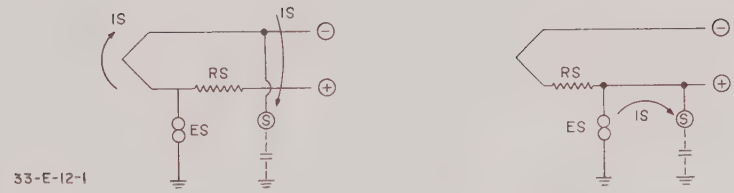
2. CONNECTIONS

a. The instrument is shipped with the shield jumper connected to the negative input terminal (V_3). This connection suffices for most primary element circuits; however, it's merely a typical connection and should be changed as necessary to improve instrument performance. The shield connection should eliminate or minimize the effects of voltage to ground stray pick-up. The specific connection is determined by the magnitude of the stray, with respect to the instrument span; the magnitude and distribution of the source impedance; and the location of stray signal injection by the source. In general, the instrument shield should always be connected to the primary element circuit lead which has the lowest impedance to ground to prevent passing current through the higher source impedance, as shown in figure 3.

b. In figure 4, various types of primary element circuits have been reduced to equivalent circuits (A, B, and C) which show the distribution of source impedance and the points at which the source might possibly be grounded. Determine the equivalent circuit for the primary element and connect the shield according to the data listed in Table 1.

TABLE 1
SHIELD CONNECTIONS FOR EQUIVALENT SOURCE CIRCUITS

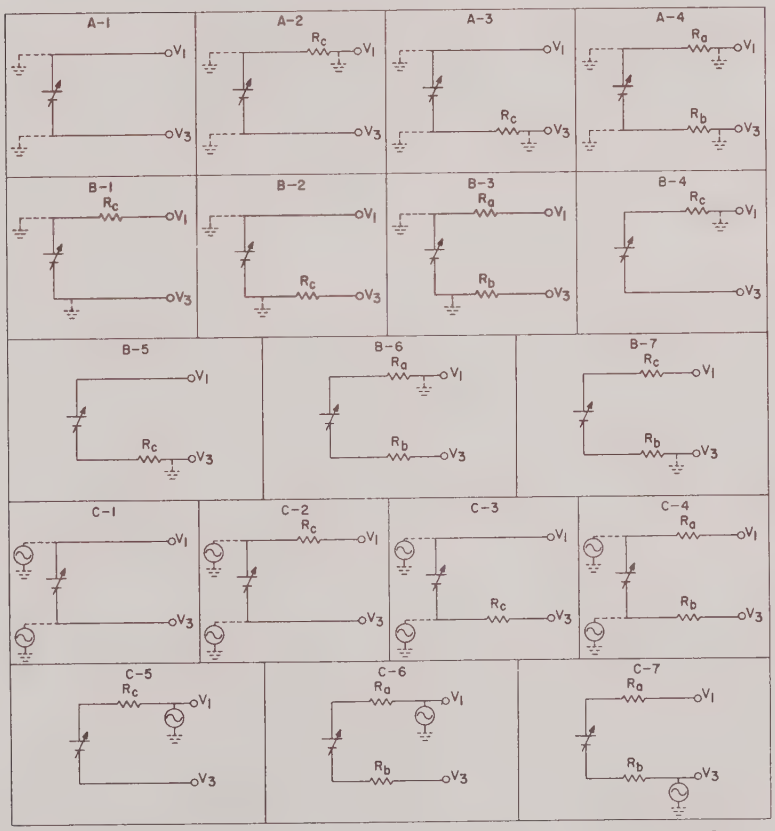
Magnitude of Stray to Ground	Total Source Impedance (R_o)	General Category	Specific Case	Shield Connection
Less than 1 volt per millivolt of span	Less than 1000 ohms	Type A circuits	All type A circuits	Connect shield to terminal
	1000 to 10000 ohms	Type B circuits	B_1,B_5,B_7; also B_3 if R_a is equal to or much greater than R_b	Connect shield to terminal V_3
			B_2,B_4,B_6; also B_3 if R_b is greater than R_a	Connect shield to terminal V_1
Greater than 1 volt per millivolt of span	0 to 10000 ohms	Type C circuits	C_1,C_2,C_7; also C_4 if R_b is less than 100 ohms and if R_b is less than R_a	Connect shield to terminal V_3.
			C_3,C_5,C_6; also C_4 if R_b is less than 100 ohms and if R_a is less than R_b	Connect shield to terminal V_1.
			C_4 if both R_a and R_b are high (above 100 ohms)	Enclose the input leads in a shielded cable and connect the shield lead to the SHIELD connection on the terminal panel.



⊖ NEGATIVE INPUT TERMINAL
⊕ POSITIVE INPUT TERMINAL
Ⓢ SHIELD TERMINAL

RS SOURCE IMPEDANCE
IS STRAY CURRENT
ES STRAY SOURCE

Figure 3. Typical Shield Connections



Legend of Symbols

	Variable Voltage, no a-c source to ground
	Variable Voltage, a-c source to ground
R_c	Customer's total source impedance or resistance, unilateral distribution
$R_a + R_b$	Equal to (R_c) customer's total source impedance or resistance. R_a and R_b may be equal or unequal. Equal distribution is of greatest significance in equivalent circuit C_4
V_1 and V_3	Instrument terminals, V_1 (+); V_3 (−)

Figure 4. Equivalent Source Circuits, schematic diagram

1. GENERAL.

A primary element is a device which supplies an input signal to a measuring circuit. The primary element and a particular measuring circuit associated with that primary element constitute an actuation. Information concerning the installation of primary elements for both (millivolt and thermocouple) actuations is included in this section.

2. MILLIVOLT ACTUATION.

Instruments which have a millivolt actuation are supplied with an uncompensated measuring circuit, since the error signal will be obtained from a d-c millivolt source. The primary element must be installed in accordance with the instructions provided by the manufacturer. Use insulated copper wire for connections between the primary element and the plus (+) and minus (-), terminals on the instrument input panel.

3. THERMOCOUPLE ACTUATION.

a. GENERAL. A thermocouple is a circuit of two dissimilar metals welded together to form a measuring junction; it is used to measure temperature in terms of the difference in emf between the measuring junction and the reference junction. The measuring circuit associated with a thermocouple primary element uses a copper resistor to compensate for variations in the temperature at the reference junction. The location, connection, and method of installing thermocouples and accessories are left largely to the discretion of the user. For satisfactory results, however, observe the general recommendations and precautions presented in the following paragraphs.

b. LOCATION AND MOUNTING. Do not locate a thermocouple in a stagnant area or where it will come in direct contact with flame. Instrument readings will not then be representative of the process temperature; direct flame will materially shorten the life of the thermocouple or the protecting tube. When measuring high temperatures install the thermocouple vertically, if possible, to prevent the protecting tube from sagging. For permanent installations, mount thermocouples with adequate support. They must be protected from mechanical injury; particularly make sure they will not be subjected to severe jarring or vibration. Use a tube or well to protect a thermocouple from harmful gases, corrosive liquids, and mechanical damage. A tube will also provide support, particularly for longer length couples, when horizontal installation is required in high temperature applications.

c. INSERTION. Extend the measuring (hot) junction well into the heat to assure correct temperature readings and to avoid conduction errors. Conduction error is especially troublesome where metal protecting tubes are used for short insertions. Short insertions of three to four inches beyond the inner wall surfaces of a furnace or oven may yield satisfactory results if the walls are brick-lined or heat-insulated. Short insertions may also be satisfactory for measuring the temperatures of high velocity gases or flowing liquids. The installation of thermocouple protecting tube assemblies in typical applications is described in detail

in a later paragraph. To measure liquid temperature in small diameter pipe lines which are not insulated, install the thermocouple and protecting well in a T-fitting or elbow. This permits the well to be in contact with the liquid over a distance of several inches from the measuring junction.

d. MAINTENANCE. It is frequently desirable to check thermocouples periodically against a reference standard (a new thermocouple of the same type will usually do). Preferably check thermocouples under normal operating conditions without removing them from the installation. Insert the reference standard in the same protecting tube as the used couple or install it adjacent to the used couple. Where installation conditions do not permit such a procedure, and operating conditions are relatively constant, determine the average life of several couples in your application and set up a periodic replacement schedule. Replace thermocouples before they deteriorate beyond the desired limits of accuracy. Do not use thermocouples with burned-out protecting tubes. Replace the tube before the thermocouple is damaged.

4. EXTENSION WIRE.

a. GENERAL. Use extension wire of the proper type between the connection head and measuring circuit input terminals in the instrument. (Each type of extension wire is made from a pair of conductors especially selected to have a temperature-emf relationship which matches that of a particular type of thermocouple).

b. INSULATION. Use extension wire with the proper type of insulation to meet your requirements. The maximum recommended ambient temperature limits for the most frequently used insulating materials are given in Table I. Note that all extension wire is matched for use within certain ambient temperature limits, usually 0 and 400°F but at least as high as the maximum limit for which the insulation is suitable.

TABLE I

RECOMMENDED MAXIMUM TEMPERATURE LIMITS
FOR EXTENSION WIRE INSULATION

Type of Insulation	Maximum Temperature °F
Rubber (other than Buna S)	167
Lead-covered-Weatherproof	221
Polyvinyl over Polyvinyl	221
Rubber (Buna S)	140 (minimum - 65)
Asbestos	400
Fibre Glass	400

c. INSTALLATION. Use continuous lengths of extension wire whenever possible. If splices are required, solder or weld them, and insulate in a manner comparable with the existing insulation. Protect extension wire from mechanical damage by running it through suitable conduit or other covering from the connection head to the instrument case. If rigid conduit is used connect it to the instrument with about 18 inches of flexible conduit.

NOTE: Do not run extension wire in the same conduit with power cables.

d. POLARITY. Be careful to observe correct polarity in connecting extension wire to the connection head and to the instrument terminal block. Terminals are marked (+) and (–) as shown on the wiring diagram. Extension wire polarity is identified by color coding. The tag attached at shipment to wire supplied by Brown Instrument Division tells the color used on the positive and negative conductors (negative conductor on all standard wire has red insulation or a red wrap). Save this tag, or before destroying it, make a note of this information.

e. WIRING AT CONNECTION HEAD. Differences in thermoelectric characteristics between thermocouples and extension wires will cause erroneous instrument readings if the ambient temperature at the connection head, or at the point where the thermocouple and extension wires are joined, exceeds the recommended limit for a given type of extension wire. Take the following precautions to minimize the possibility of such errors:

(1) Pack the space between the protecting tube and the opening through which it is inserted with asbestos wool or a suitable refractory cement.

(2) Allow sufficient space between the walls or roof of the process and the connection head to prevent excessive heating of the head.

(3) Shield the connection head from any adjacent source of heat.

TABLE II

MAXIMUM TEMPERATURE LIMITS (°F)

REFRACTORY PROTECTING TUBE MATERIALS

Type of Tube	Material	Temperature
Primary	Sillramic Quartz	3000°F 2300°F
Secondary	Silica Firebrick Durax (Silicon carbide) Mullite	2900°F 2450°F 3000°F 3000°F

f. PROTECTING TUBE.

(1) General. While the use of metal protecting tubes requires no particular precautions, refractory protecting tubes are fragile and must be handled with care. Do not subject them to excessive physical or thermal shock. Table II lists the maximum temperatures to which various refractory protecting tube materials may be safely subjected under oxidizing or reducing conditions. On horizontal installations, the unsupported section of a tube may sag if used above the limits shown.

The maximum safe heating rates for various kinds and sizes of tubes are listed in Table III. Preheat tubes at the rate given in this table, and illustrated in the examples following the table. Similarly, in removing tubes, avoid subjecting them to sudden changes in temperature. Withdraw them slowly, preferably at about the same rate they were inserted.

(2) Examples

Example 1 - Conditions are:

(a) A Sillramic protecting tube (O.D. - 11/16", wall thickness - 1/8", length - 15" at room temperature (75°F) is to be installed through a furnace wall (thickness - 12").

(b) The entrance temperature is 200 to 400°F and the maximum temperature is 2600°F.

(c) The temperature gradient between the entrance and the maximum temperature is not abrupt.

Refer to Table III and note that the safe heating rate for an 11/16" O.D. Sillramic protecting tube is 750°F/minute. To install the tube, rest the closed end inside the furnace opening for approximately 15 seconds. Advance it at the rate of 750°F/minute. The total time required to advance from 300 to 2600°F is thus approximately 3-1/2 minutes.

TABLE III

MAXIMUM SAFE HEATING RATES

FOR REFRACTORY PROTECTING TUBES

Protecting Tube Maximum Dimensions (Approximate)		Heating Rate in Degrees F per Minute					
		Type of Protecting Tube Material					
O.D.	Wall Thickness	Firebrick	Sillramic	Durax	Mullite	Silica	Quartz
1/2"	1/8"	---	1000	---	---	---	1000
3/4"	1/8"	---	750	---	---	---	----
1"	1/16"	---	500	---	---	---	----
2"	1/2"	300	---	300	300	---	----
3"	3/4"	250	---	250	250	---	----
3"	1"	200	---	200	200	200	----

Example 2 - Conditions are the same as in Example 1, except that:

(a) The entrance temperature is 800 to 1200°F.

(b) The temperature gradient between the entrance and maximum temperature is abrupt.

Preheat the closed end of the protecting tube by holding it at right angles to the thermocouple opening for 30 seconds to one minute. After preheating, insert the closed end about one inch into the furnace and continue to heat it for another 30 seconds. Now advance it at the rate of 750°F/minute. Total insertion time from 1000 to 2600°F is about two minutes.

Example 3 - Conditions are the same as in Example 2, except that the furnace is under positive pressure and there is a flame at the thermocouple tube opening.

CAUTION: Never thrust a cold tube directly into the flame; advance it slowly toward the flame as preheating progresses.

Usually 1 to 2 minutes (depending upon flame conditions) will be required to preheat the tube sufficiently before installing it in the furnace opening. Thus, the tube should be advanced toward the opening at a

slow uniform rate, until the closed end is installed approximately 1" in the furnace opening. Allow 1/2 minute more to further preheat the tube at this point. If flame conditions are not severe, the installation may be completed in 2 to 4 minutes. Where flame conditions are severe, the tube must be heated to a considerably higher temperature before it is installed.

Example 4 - Installing Sillramic tubes in High-Temperature Salt Baths:

(a) Put the thermocouple-protecting tube assembly on top of the salt bath furnace. Shield the tube from direct heat radiation from the bath. Preheat in this manner for several minutes.

(b) Place the assembly so that the lower eight to ten inches of the tube receive radiant heat from the bath surface. Turn the tube over every minute or two for a period of eight to ten minutes, so that it will be heated uniformly.

(c) Move the heated end of the tube toward the bath at a rate of about one inch per minute; during this time dip the tube into the bath for about one or two seconds out of every 30 seconds. As the tube becomes hotter, slowly increase the immersion time.

(d) Observe the tube each time it is withdrawn. The tube is sufficiently preheated when salt no longer solidifies on it. Complete the installation.

(e) Locate the tube permanently where it is least likely to be damaged, and where it will be most responsive to all temperature changes of the salt. Keep the end of the tube at least one inch away from electrodes and from the side of the salt pot.

NOTE: Do not remove a Sillramic tube from the pot as long as the salt is in a molten state. If the bath is shutdown, however, remove the tube before the salt cools enough to solidify.

1. PLACING IN OPERATION

a. Check that all connections are as specified in the installation diagrams.

b. Switch on instrument power and allow the instrument to warm up for at least 30 minutes (2 hours for highest accuracy on thermocouple actuations) to stabilize internal temperature and be sure the measurements obtained are within the calibrated accuracy of the instrument. Switch on power to the chart drive system when recording is required.

c. If required by the application, remove the instrument door as follows:

(1) Swing door open.

CAUTION: The door comes off quickly, so have a firm grip on it before releasing the door latch.

(2) Lift door latch (figure 1) and pull with an out and upward motion to free door from instrument.

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Figure 1. Releasing door latch for door removal.

2. CALIBRATION

The instrument is adjusted, calibrated, and inspected before it leaves the factory, and is ready for use when received. Instrument calibration, however, should be checked periodically and adjusted when necessary as specified in the servicing procedures.

3. SHUTDOWN

a. **GENERAL** If the instrument will be inactive for a short time period, merely switch off chart power; the amplifier will remain energized. If the instrument will be out of service for a week or more, or if service procedures are to be performed, turn off the main power switch. For pen dragging instruments which will be shut down for a week or more, evacuate the ink supply and flush out the ink system with water to prevent ink drying in the system.

b. USING INSTRUMENT AS AN INDICATOR ONLY.

(1) Instruments with a-c servo motor. On single-record or multirecord instruments with an a-c servo motor, the line winding of the servo motor is energized through the main power and chart switches. As an option, the chart switch can be bypassed so that the servo motor is energized through the main power switch only. This permits using the instrument as an indicator simply by turning off the chart switch. If this wiring option was not specified, the change can be made in the field by switching off instrument power and moving the white wire of the servo motor from terminal Wcs to terminal Wps on the amplifier-motor terminal block.

NOTE: When using a multirecord instrument as an indicator, turn off the chart switch immediately after the number of the desired record appears in the window of the printing mechanism.

(2) Instruments with d-c servo motor. These instruments can be used as indicators simply by switching off power to the chart motor.

4. RELATED PROCEDURES

Additional procedures, if required by the features and options supplied with this instrument, are specified later in this manual.

CHART OPERATION

1. GENERAL

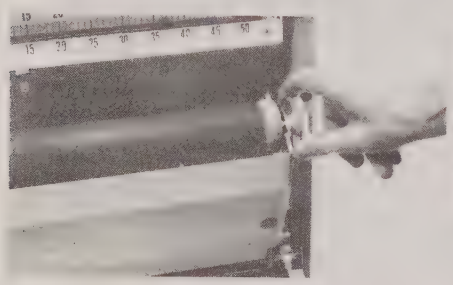
Standard strip charts are 122 feet long. The words RENEW CHART are printed at regular intervals on the last few feet of chart paper. The chart can be changed without withdrawing the chassis from the case or interrupting instrument balancing or controlling operations.

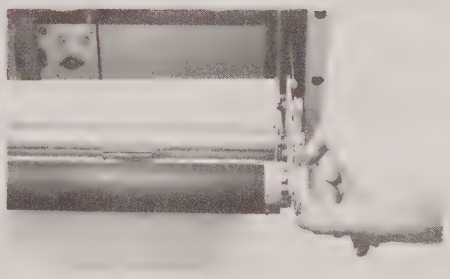
2. INSTALLATION

a. Install the chart for continuous, automatic reroll as follows. If the instrument has a chart saver device (optional) see paragraph 3, below.

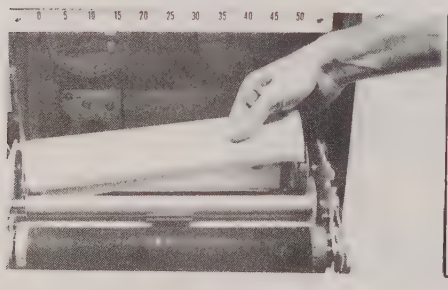
1

Squeeze release latch and lower chart transport.



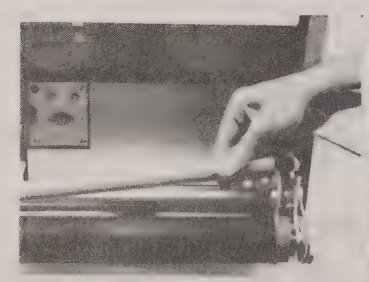


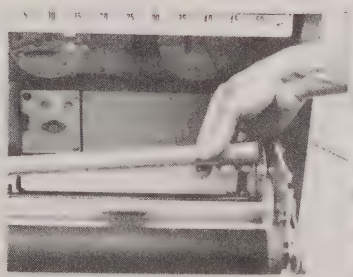
2 Grasp chart advance knob and swing transport through 90° arc.

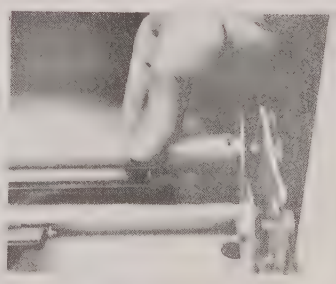


3

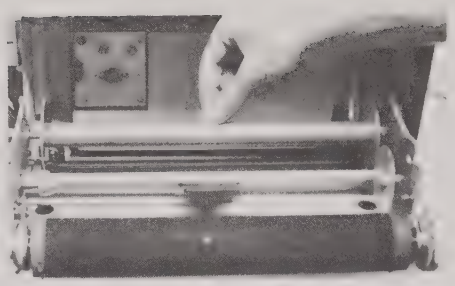
Press used (rerolled) chart against spring loaded spindle, swing right end forward, and remove chart roll.





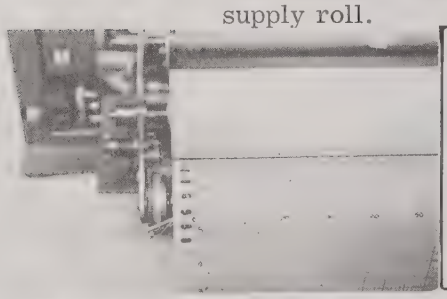


4 Remove empty supply roll from supply spindles and place on reroll spindles. (Empty supply roll will serve as reroll tube for new chart.) Be sure right hand spindle locks into notch in reroll tube.



5 Remove tape from free end of new chart roll and attach tape to reroll tube.

6 Place new chart roll on supply spindles so that chart unwinds from bottom. Make sure right hand spindle locks into notch in supply roll.



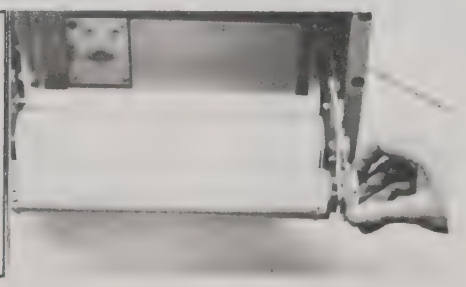
7

Unwind about 12 inches of chart paper and pass it over chart drum. Line up holes in chart paper with sprockets in chart drum.

8 Feed chart around front of transport (not around chassis pull bar) and attach free end of chart to tape on reroll tube.

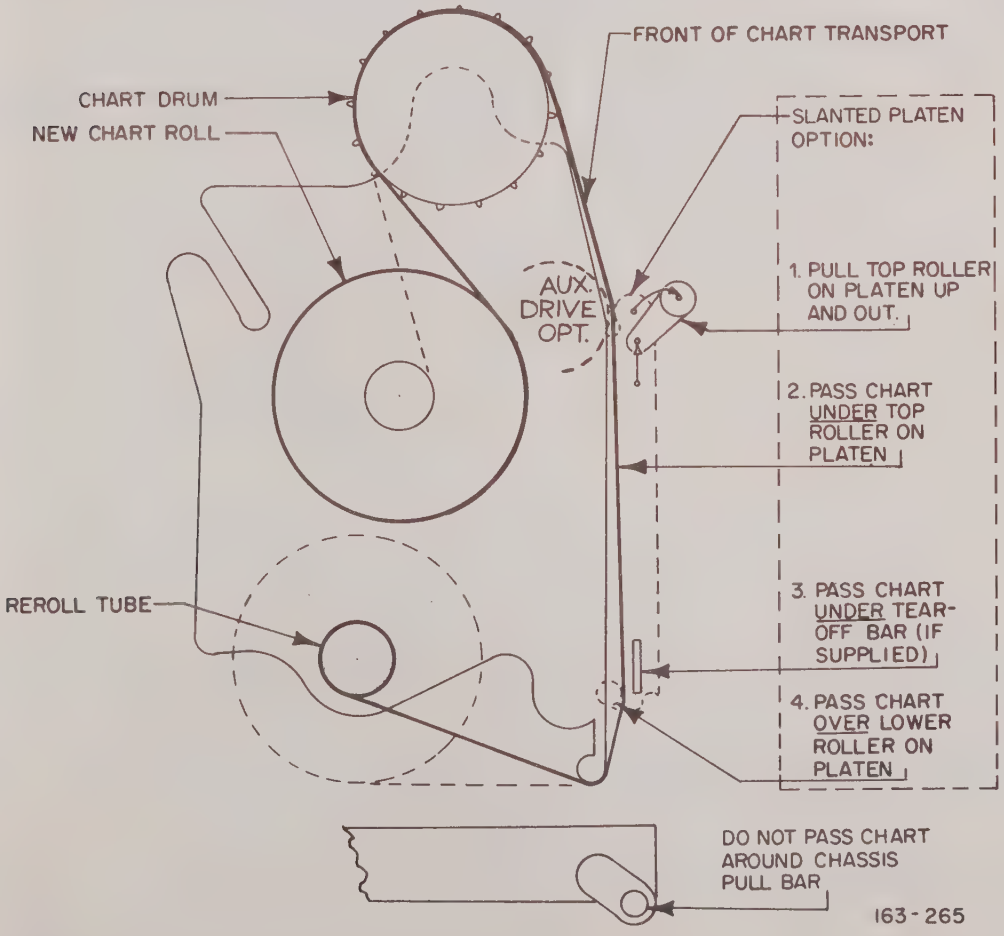
9

Turn chart advance knob to be sure that chart rerolls smoothly and evenly.

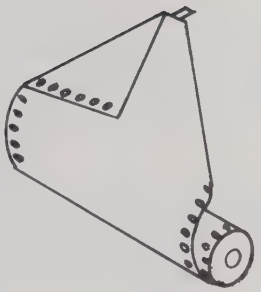


10 Raise chart transport, then lock release latch.

b. Time lines run horizontally on the chart. Before energizing the chart drive mechanism, turn the chart advance knob to align the correct time line with the pen.


FRONT OF CHART TRANSPORT
CHART DRUM
NEW CHART ROLL
SLANTED PLATEN OPTION:
AUX. DRIVE OPT.
1. PULL TOP ROLLER ON PLATEN UP AND OUT.
2. PASS CHART UNDER TOP ROLLER ON PLATEN
REROLL TUBE
3. PASS CHART UNDER TEAR-OFF BAR (IF SUPPLIED)
4. PASS CHART OVER LOWER ROLLER ON PLATEN
DO NOT PASS CHART AROUND CHASSIS PULL BAR
163-265

c. Some people prefer to cut or fold back the chart along the leading edge. This technique was originally intended for those instruments that require the chart to be fed through narrow slots. Some find that the chart also rerolls better this way. When using the chart saver this is a distinct advantage.



3. CHART INSTALLATION WITH CHART SAVER OPTION

a. The chart saver option consists of a wooden reroll bobbin connected to a spring clip through a retractable tape. When daily records are torn off the chart, the clip can be pulled up to the end of the chart, saving about 12 inches of chart paper.

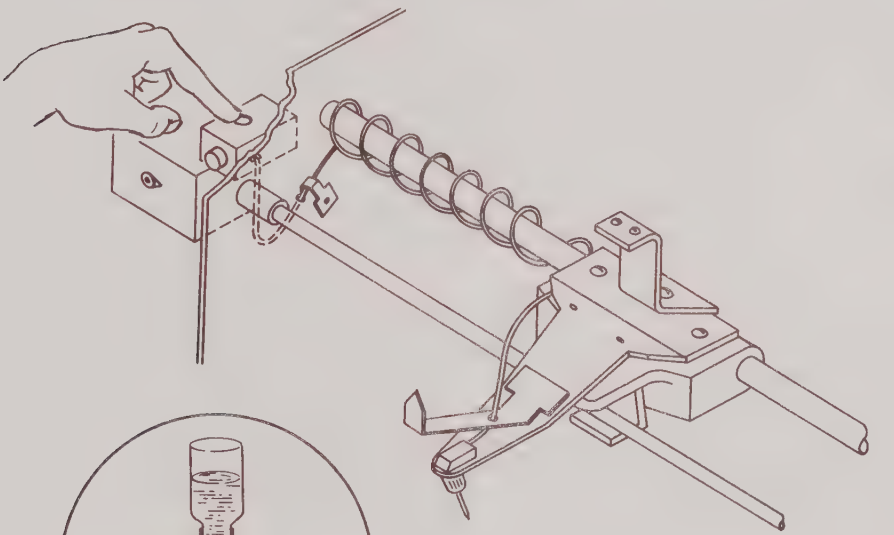
b. Chart installation on instruments with the chart saver are the same as described above with the following exceptions.

(1) Discard the empty supply roll tube.

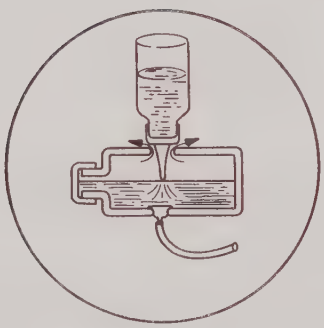
(2) After winding the chart as shown in the preceding illustrations, attach the spring clip to the end of the chart. Release spring clip, allowing tape to recoil and place chart under tension.

1. GENERAL

The ElectroniK 16 Strip Chart Recorder uses the capillary type remote reservoir recording pen system, shown in figure 1. The indicator carriage and sapphire-tipped pen assembly are positioned by the servo drive cable. A separate plastic ink reservoir, remotely located in the ink compartment, supplies ink to the pen through a coiled ink delivery tube. This design features clear and reliable recording in conjunction with a generous 1-ounce ink supply and permits refilling the reservoir while the instrument remains in operation.



163-29



163-30

2. FILLING AND STARTING

a. The drawer type ink compartment is located on the front panel of the instrument chassis. Use the knob provided to pull out the tray and gain access to the reservoir.

CAUTION: Do not use any ink other than the type supplied with the instrument. Other types of ink may clog the system and make unsatisfactory records. When a new ink supply is required, refer to the parts list for ordering data.

b. Using the squeeze bottle of ink supplied in the accessory kit, fill the ink reservoir to within 1/4 inch (approximately) of the top. Do not overfill.

NOTE: Don't block the filler hole in the reservoir with the neck of the supply bottle, allow space for air to escape (figure 1).

c. Either raise the pen off the chart (if the manual pen lifting device is provided) or lower the chart housing away from the pen assembly. Place a paper towel or blotter under the pen tip.

d. Place a finger over the filler hole in the ink reservoir and press down to force ink through the capillary system. Slide your finger off the filler hole and release pressure on reservoir. Several pumping actions may be required to completely fill the coiled ink delivery tube and the pen assembly. Force ink through the pen tip until it flows in a steady stream.

e. Replace the pen on the chart; it should start writing at once. If it doesn't, place a finger over the filler hole in the reservoir and press gently.

3. CLEANING

a. Clean the pen tip every month as follows:

(1) Lower the chart carriage away from the pen assembly, and place a paper towel under the pen tip.

(2) Place a finger over the filler hole in the ink reservoir and gently squeeze the reservoir to force a steady stream of ink through the pen tip.

(3) Swing the chart carriage back into the normal recording position.

b. The routine cleaning described above should remove any paper fibers or bits of dust collected by the pen tip. If this material is permitted to accumulate it can prevent normal ink flow and cause skipping.

c. If the pen is clogged or sealed by dried ink, use a fine wire (.005 dia.) to clear the opening. Lower the chart housing and push the cleaning wire through from the front of the pen tip.

NOTE: Never touch pen tip with fingers; oil film could clog tip.

d. Should the system contain dried ink, you may have to flush the entire system as follows:

(1) Apply pressure to the ink reservoir to remove air, then place a finger over the filler hole and release the pressure; this causes the ink to be extracted from the system. Repeat until all the ink has been returned to the reservoir.

(2) Empty reservoir and refill it with a detergent solution. Replace it and apply pressure to the reservoir to flush the solution through the system.

NOTE: A solution ratio of one teaspoonful of a low level controlled suds detergent in a gallon of water is recommended. Never use chemicals for cleaning, they may attack the pen system.

(3) Be sure to remove all traces of the detergent solution and flush the system with water. Remove as much of the water as practical before refilling the reservoir with ink. A small amount of detergent in the ink will reduce the surface tension of the ink and cause feathering of the record.

1. GENERAL

a. Adherence to a routine inspection and maintenance program will insure optimum instrument performance and should reduce servicing requirements to a minimum. The checks and maintenance procedures included in this section are recommended to supplement normal industrial cleaning procedures.

NOTE: The frequency of periodic maintenance is a function of instrument operating time and balancing speed. For example, an instrument with a 0.2 second balancing speed may require more frequent maintenance than one with a 5 second balancing speed for the same number of operating hours. For continued satisfactory performance, establish a regular maintenance schedule in accordance with the instrument operating cycle. Include in the maintenance schedule the inspection of items such as relays, Micro Switch units, slidewire contacts, two speed gear box clutches and other parts subject to wear.

b. You can perform some maintenance with the instrument in service; but for certain procedures such as performance checks, you will have to shut down the instrument.

2. RECORDING SYSTEM

a. **RECORDING DEVICE.** Pen, printwheel, etc. are described elsewhere in this instruction (see table of contents).

b. **CHART.** Replace the chart when the warning RENEW CHART appears on the chart in service. Many people calculate how long a chart will last at the specific chart speed used, and replace charts periodically.

c. **SCALE.** Clean the scale (in place) as often as required to remove dirt, grease and ink. Use a soft cloth and a soap and water solution. Never use alcohol base solvents which may attack the lacquer finish of the scale.

3. DRIVE SYSTEMS

a. **CHART DRIVE.** Clean the gears of the chart drive system whenever required; use a stiff bristle brush.

b. **INDICATOR CARRIAGE DRIVE.** Instrument slidewires having exposed convolutions and contactors require periodic maintenance. Examine the slidewire and contactor assembly every month. When required, replace the contactors and wipe the slidewire convolutions with a dry lintless cloth or paper towel. Wipe the drive cable off with a clean dry cloth to remove any oil or dirt. Clean the servo drive gear with a stiff bristle brush when required.

NOTE: If the slidewire contactors are replaced, check instrument calibration (Service Section).

c. SELECTOR SWITCH (MULTIPOINT INSTRUMENTS). The input selector switch, which is geared to the chart drive system, requires periodic cleaning. With power off, disconnect electrical plug(s) between chassis and case, disconnect telescoping shaft, and remove chassis from case. Remove selector switch cover and, if necessary, clean switch wiper and segments with solvent (carbon tetrachloride or similar). Replace cover and restore normal connections.

4. CONTROL SYSTEMS (PROPORTIONING RESISTORS)

Instruments supplied for proportional control have a proportioning resistor(s) which requires the following maintenance.

a. TYPE I RESISTOR. The "pancake" type resistor, mounted in a dust resistant enclosure, may be easily inspected by removing the enclosure cover. If necessary the contactors, contact ring and contact surface of the resistor may be wiped clean with a lint free cloth.

CAUTION

(1) Shut off power to the instrument before opening resistor enclosure.
(2) Do not bend contactor arms.
(3) Do not use abrasives, solvents, or oil of any kind on resistor winding.
(4) Replace resistor enclosure cover carefully; do not snag or entangle drive cable.

b. TYPE II RESISTOR. The "cartridge" type resistor is not enclosed and may require more frequent examination and cleaning. As often as necessary, clean the contactor and bare portion of the resistor with a lint free cloth. Observe the same precautions as stated for Type I.

LUBRICATION **MAINTENANCE**

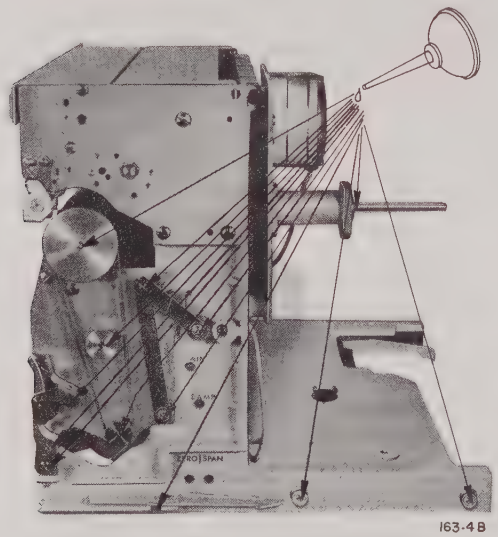
1. GENERAL

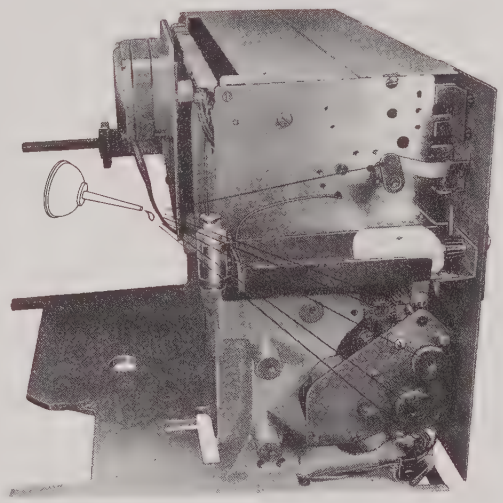
a. A 2-ounce bottle of type L-1* oil is supplied with the instrument for lubrication. You can get this oil in 1-ounce bottles from Honeywell, Philadelphia Division; Specify part number 79329.

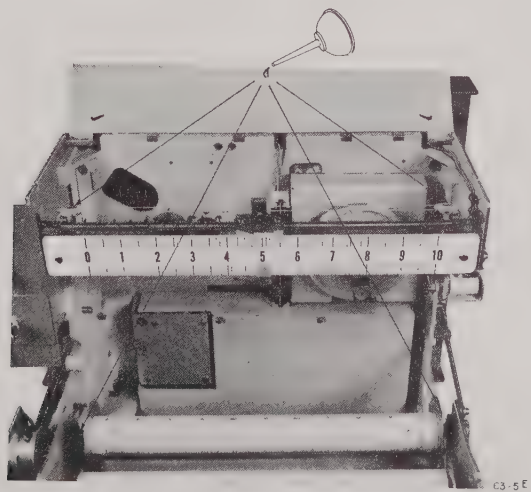
b. Wipe any dirt accumulation from the areas to be oiled before oiling.

c. The motors are factory lubricated and do not require periodic lubrication.

d. Once a month, oil lightly at all the points indicated on the following lubrication diagrams.







* *Honeywell Material Spec. B-553.*

e. Some typical lubrication points are identified in the illustrations; be sure to lubricate:

(1) All gear bearings on the chart drive mechanism.
(2) All chart drive gear bearings on the chart carriage.
(3) All pivot points and bearings on the chart carriage, including the chassis handle pivots.
(4) Ink compartment guide bearings.
(5) Instrument chassis guide bearings.
(6) Servo drive shaft bearing.
(7) Bearings on the guide pulleys for the drive cable.
(8) Apply light grease to channel tracks in chassis, if necessary.

NOTE: Never lubricate the drive cable(s) or pen carriage guide bars.

INSTRUMENT **THEORY**

1. GENERAL

a. This instrument uses a potentiometric rebalancing system as illustrated by the servo loop shown in Figure 1. The basic servo loop includes the primary element, measuring circuit, amplifier, servo motor, and indicator.

b. The primary element continuously detects the value of the measured variable and sends an input signal to the instrument; the input signal (Ein) will be proportional to the magnitude of the measured variable.

c. The measuring circuit determines the millivoltage drop across the slidewire while the position of the slidewire contactor assembly determines the magnitude of the feedback signal (E fb).

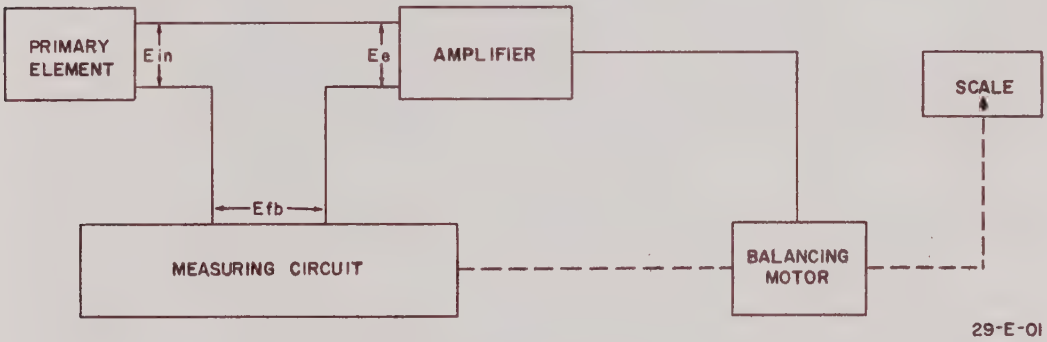


Figure 1. Simplified Servo Loop.

2. BALANCE

a. The feedback signal (E fb) and the input signal (E in) are compared by the amplifier circuit (by cancellation) and the difference, or error signal Ee, is then amplified. The error signal is usually on the order of a few microvolts (dc); first it's converted to a proportional a-c signal and then amplified to drive the servo motor. The servo motor responds to the error signal by rebalancing the measuring system which simultaneously repositions the indicator assembly and changes the magnitude of the feedback voltage until the error signal is reduced to zero. At balance Ein and Efb are equal and Ee is zero. If Ein is greater than Efb, the polarity of Ee will be (+) and the indicator will be driven upscale; if Ee is negative (Efb greater than Ein) the indicator will be driven downscale.

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3. DAMPING

Any self-balancing system is inherently oscillatory because the inertia of the moving parts prevents the system from stopping exactly when the balance point is reached. To obtain a satisfactory balance action it is necessary to introduce a feedback loop which, in effect, anticipates the final balance point and causes the system to decelerate before the balance point is reached. The system inertia then causes a rapid drift into the balance position.

1. MILLIVOLT ACTUATION (basic circuit)

a. GENERAL

(1) The millivolt actuation can be considered as the basic potentiometer type measuring circuit. It receives an error voltage from any sensing element having a millivolt output. The measuring circuit schematic is shown in figure 1. All other circuits are modifications of this basic circuit.

(2) The output of the constant voltage circuit is applied across the parallel resistances of the measuring circuit branches and causes a 6-milliampere total current to pass through the equivalent resistance of the measuring circuit (343.33 ohms). This current divides in accordance with the resistance ratios of the various circuit branches. Current limiting resistors in each branch maintain 4* milliamperes through the upper branch and 2* milliamperes through the lower branch. (The terms upper and lower branches merely refer to the locations shown in the schematic diagrams).

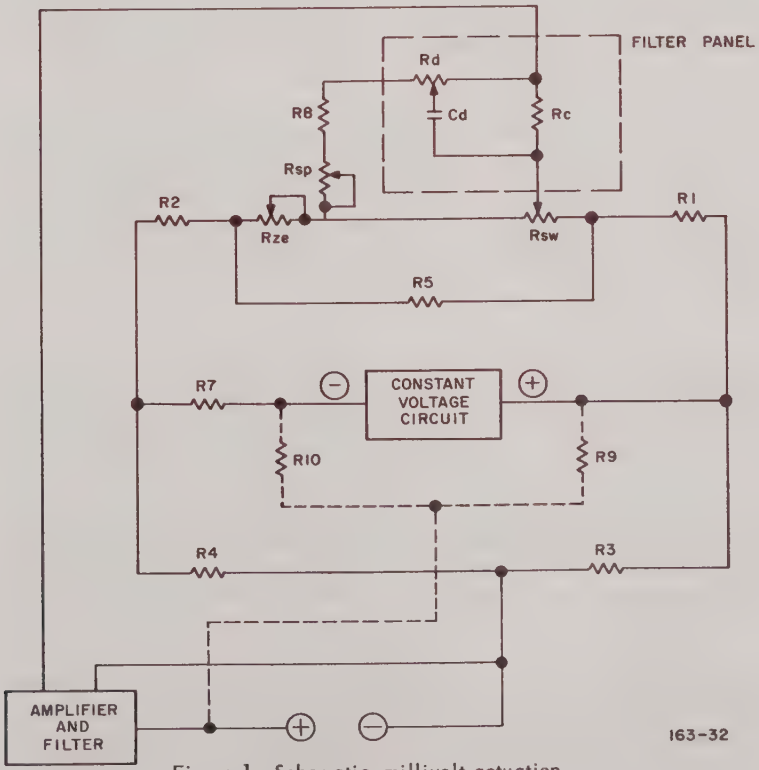

Figure 1. Schematic, millivolt actuation.

On spans greater than 51 millivolts these currents are 5.5 and 0.5 milliamperes respectively.

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b. RESISTORS

(1) The upper branch of this circuit consists of the positive suppression resistor and the current limiting resistor (R2 and R1 respectively) and the span network which includes the combined resistance of the slidewire (Rsw), the zero adjustor (Rze), the span adjustor (Rsp), and the shunt resistor R5. The lower branch of the millivolt circuit consists of the current limiting resistor R3, and the negative suppression resistor R4. Resistors R1, R2, R3, R4, and R5 are all range resistors; their values are determined by the instrument range.

(a) While R1 can be considered as being a span network component, its value is not changed in order to change the span. When the span is changed by varying the resistance of R5, the current distribution is maintained through the span network and through the positive suppression resistor R2, by modifying the value of R1.

(b) The value of the span resistor R5 is a primary factor in determining the current flow in the upper branch of the measuring circuit, which in turn determines the voltage drop across the slidewire or span network, and hence establishes the nominal instrument span.

(c) R3 maintains a constant current through the lower branch of the circuit on millivolt actuations. On compensated actuations the value of R3 is selected to maintain the required current flow in the reference junction compensation spool. On uncompensated actuations the value of R3 depends on the value of the negative suppression resistor R4.

c. SPAN

(1) The span of the instrument is determined by the current flowing through the slidewire. This current, and therefore the span, is determined by resistor R5 and the fine span adjust rheostat Rsp.

(2) The span adjustor provides a voltage divider action (in conjunction with the span network) permitting critical adjustment of the balance position feedback voltage, and effectively changes the span.

d. ZERO

(1) Division of the upper branch into three sections permits determination of reference voltages corresponding to 0% and 100% of scale, i.e., both limits of slidewire travel. The voltage drop developed across the combined resistances of R2, Rze, and R4 causes the instrument to read 0% full scale when the primary element produces a voltage equivalent to 0% full scale.

(2) The zero adjustor permits a linear shift of the zero position and all other points on the instrument scale without significantly affecting the instrument span. This adjustor is effectively an extension of the suppression resistor and permits critical determination of the zero position. Decreasing the portion of Rze used in the circuit causes all points to shift upscale; a downscale shift results when the effective resistance is increased.

(3) R8 is an additional resistor used to maintain the branch currents required for millivolt ranges with spans greater than 51 millivolts.

e. SUPPRESSION

(1) Positive suppression (giving 0% full scale position a positive value above zero) is obtained by a voltage drop across the R2 spool and the zero adjust rheostat Rze.

(2) Negative (sub-zero) suppression of the 0% position is possible since the lower branch of the measuring circuit is divided into two sections and the input signal is applied between this midpoint and the slidewire contactor. The magnitude of negative suppression is determined by the voltage drop across the R4 spool.

(3) Due to the zero adjustment's position in the circuit, the circuit has a positive suppression of approximately 30% of span when R2 and R4 are both zero. Therefore, any range which has a positive suppression less than 30% of span uses resistance in the R4 position.

f. BURNOUT

(1) When the burnout feature is provided, it is accomplished by the addition of either R9 or R10, which provide upscale or downscale indicator carriage drive respectively.

(2) The burnout resistor develops a voltage drop between the measuring circuit and the amplifier. The polarity of this signal determines the direction of servo drive upon an open circuit in the input. R9 applies a positive voltage to amplifier terminal F in order to drive the system upscale; R10 provides a similar negative voltage for downscale drive.

(3) Resistor R7 has a value of 10 ohms and is located between the negative output terminal of the constant voltage circuit and the rest of the measuring circuit. Its purpose is to develop a small voltage differential between the circuit reference potential and the negative constant voltage circuit terminal. This voltage is required to provide the downscale burnout signal.

2. THERMOCOUPLE ACTUATION

a. This actuation receives an input signal generated by a thermocouple primary element. The basic potentiometer measuring circuit is modified (figure 2) to accommodate thermocouple primary elements by the addition of the reference junction temperature compensation spool on the input terminal panel. R rj compensates for variations in the ambient temperature at the reference junction.

b. For thermocouple actuations, the value of R3 is determined by the required current through the compensation resistor, as required by the particular type of thermocouple. Therefore R1 serves only to keep the amount of current drawn from the constant voltage circuit at a constant value. The function of the R2 resistor is the same as on the millivolt actuation.

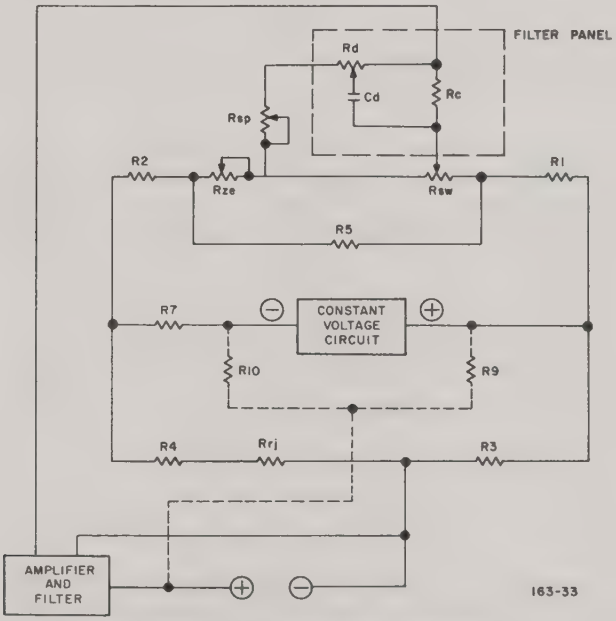


Figure 2. Schematic, thermocouple actuation

3. RADIAMATIC* PYROMETER

On measuring circuits designed for use with the Radiamatic unit the span adjustor circuit is used to compensate for non-blackbody applications. This approach assumes a ± 10% nominal span adjustment. The circuit is the same as for the millivolt actuation (figure 2).

4. TACHOMETER ACTUATION

a. The circuit used for tachometer actuations (figure 3) is essentially a millivolt circuit with a suitable voltage divider preceding it. A 1-megohm

*Honeywell Trademark.

series resistor is used for spans from 1 volt to 300 volts. A 0.1-megohm resistor (series) is used for spans less than 1 volt which cannot be handled by the standard millivolt circuit.

b. The relatively high voltage output of the tachometer generator is applied across a series-shunt-voltage divider; a proportional voltage is developed across the measuring circuit shunt resistor. The circuit is precalibrated to a standard millivolt range (10 mv). A full scale output voltage from the generator will develop the full 10-millivolt signal across the shunt resistor while any smaller output will produce a proportionally lower voltage.

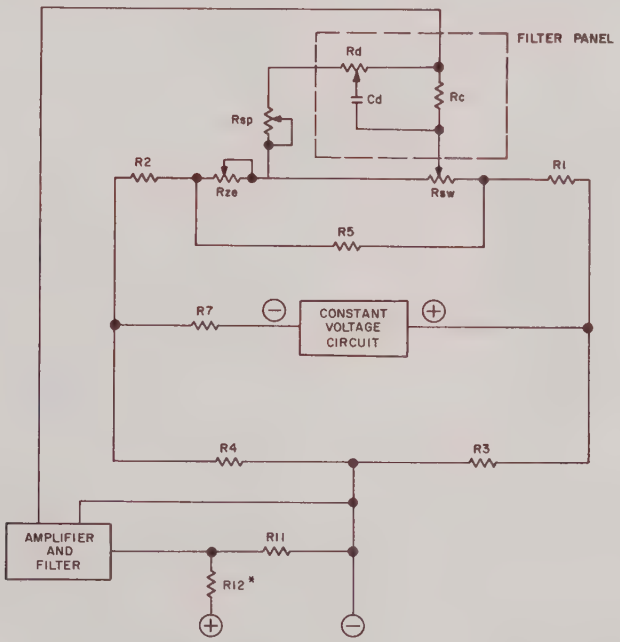


Figure 3. Schematic, tachometer, d-c volts, and d-c current actuations

5. D.C. VOLTAGE ACTUATION

This actuation is accomplished by the same basic circuit (figure 3) used for the tachometer actuations. It includes suitable series and shunt resistors that reduce the high magnitude input voltage to the range of the measuring circuit

6. D.C. CURRENT ACTUATION

The circuit for the d-c current actuation (figure 3) consists of a shunt spool (R11, across which the input current develops a voltage) in conjunction with a standard millivolt circuit. The value of R11 depends on the requirements of the signal source, but it must be between 0.5 ohm and 10,000 ohms. and must develop a millivolt span between 1 millivolt and 51 millivolts.

7. RESISTANCE THERMOMETER

a. The electrical span and suppression of the three-wire resistance thermometer circuit (figure 4) are selected to suit the sensing element and the application. Range resistors are sized to maintain the appropriate currents through each branch of the circuit. Resistors R1, R2, and the span network serve the same functions as on millivolt actuations.

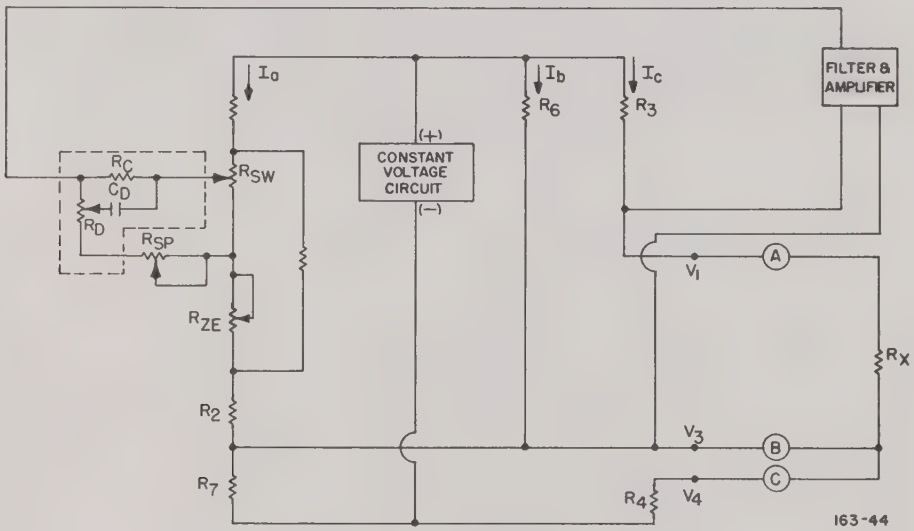


Figure 4. Schematic, resistance thermometer actuation

b. The current through the resistance element (Rx) is maintained at a constant value due to the relative magnitudes of R3 and Rx. A resistance change in Rx has no apparent effect on the current (Ic), but the voltage drop across Rx changes. This drop is nulled by the drop across the span and suppression network. Any difference between these potentials becomes the error signal to the amplifier, and rebalancing action is initiated. Thus a true null balance type resistance measurement is accomplished and the measuring circuit has an output linear to the input.

c. Leads A and B must have equal resistance, but the actual resistance magnitude is unimportant. Resistors R3 and R6 are sized to maintain the appropriate currents through leads A and B; so the equal and opposite voltage drops across these leads cancel.

d. Currents Ib and Ic combine and must pass through lead C of Rx since an equipotential (10-volt reference) is maintained between the circuit branches. The approximate resistance of lead C was considered in the calculation of R4, and variations are insignificant compared to the magnitude of R4.

1. GENERAL

This section includes procedures for the isolation of malfunctions by performance symptoms; for the isolation of defective components by voltage and resistance checks; and for the disassembly, reassembly, and adjustment of the instrument to correct for a malfunction. Wiring diagrams and check point location diagrams are included where applicable.

2. TROUBLESHOOTING PROCEDURE

The servicing procedures are intended to permit maximum analysis with minimum test equipment and minimum downtime. The following approach is used:

a. Identify the malfunction in terms of instrument performance and locate the trouble under Symptomatic Analysis.

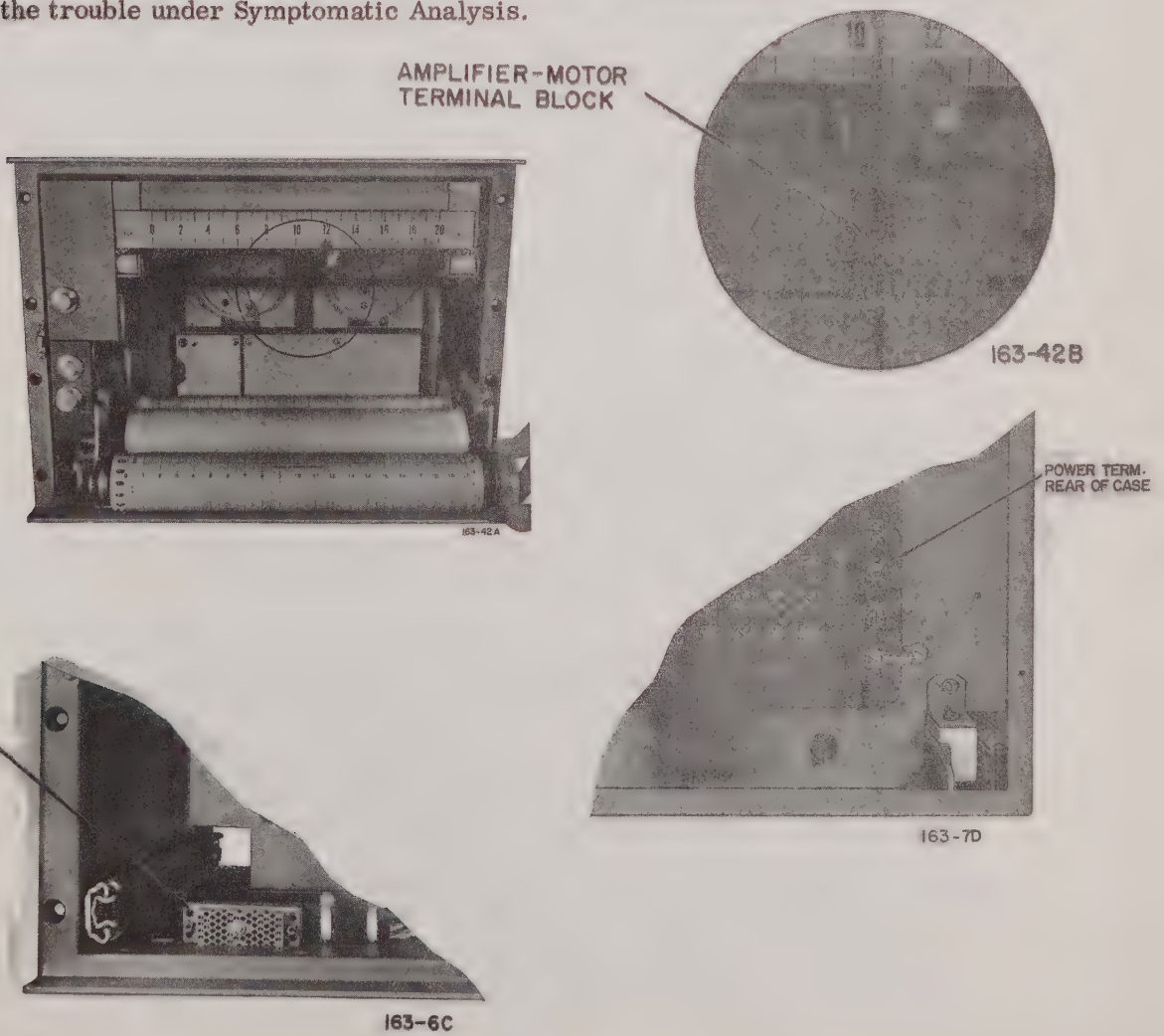


Figure 1. Test Point Locations

b. Follow the procedures to isolate the faulty component.

c. Replace a faulty component whenever possible.

d. Separate sections include troubleshooting procedures for repairing and placing some defective parts back in operation.

3. SYMPTOMATIC ANALYSIS

a. NO DRIVE

(1) Make sure the instrument and its various assemblies are being supplied with power. With instrument power switched on, check (with a multimeter) for 120 V ac at the following locations (figure 1):

(a) Between the NEUT. and HOT terminals on the input terminal panel.

(b) Between the terminals A and B on female half of the 64-point chassis connector.

(c) Between the white and black leads of the servo amplifier's 5-wire power cable (terminals W and B on the servo terminal block).

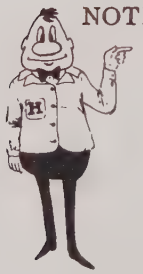
(2) Check that the cable drive system is free to move. Turn off instrument power and rotate the drive gear to position the indicator at 50% full scale. Turn the instrument power on. If the indicator does not move, the condition of 'No Drive' has been verified. If the indicator moves to either end of scale, refer to the symptom 'Drives Against A Stop'.

(3) Remove the primary element input connections and use a multimeter to check for continuity across the input terminals; observe proper polarity. The resistance should be a measurable quantity (100,000 ohms is considered an open circuit). During this test, the multimeter is applying a voltage to the instrument; if this causes the balancing motor to drive the trouble is external to the instrument. Check the primary element and its associated wiring.

(4) If the motor does not drive in step (3), connect the multimeter directly to the amplifier. Remove the 5-pin connector from the measuring circuit panel, jumper pins D and FR and connect the multimeter between pins D & F. If this causes the motor to drive, the trouble is probably in the measuring circuit or the rebalancing device; check these components.

(5) If the servo motor fails to drive in step (4), use a second multimeter to check the voltages across the balancing motor's windings. These voltages, measured at the servo terminal block (see Amplifier schematic), may be analyzed as follows:

Test Voltages		Probable Cause
Line Winding (Yellow and White Servo Motor Leads)	Control Winding (Red and Green Servo Motor Leads)	
120 Vac	0 to 7 Vac (amplifier output)	Open Line Winding or shorted capacitor (C-13)
240 Vac	20 Vdc; 0 Vac	Open control winding
240 Vac	0	Shorted control winding (balance motor should be hot) or shorted capacitor (C-14)
0	0 to 7 Vac (amplifier output)	Shorted line winding (balance motor very hot)



NOTE: If you don't have a second multimeter, use a dry cell to supply the drive signal.

(6) Replace the suspected component if a spare is available.

b. DRIVES AGAINST A STOP

(1) If the instrument has the optional burnout feature check for an open input circuit.

(2) Disconnect the primary element and connect a multimeter across the instrument input terminals (see schematic). If the instrument does not respond, reverse the connections.

(3) If the instrument responds in step (2), check the primary element and its associated circuitry.

(4) If the instrument does not respond in step (2):

(a) Check the slidewire and contactor for dirt, misalignment, or excessive wear.

(b) Check continuity of slidewire at measuring circuit connections.

(c) Check output of constant voltage circuit.

(d) Check measuring circuit resistances.

(e) Check amplifier by substitution.

c. ERRATIC

(1) Shake the various internal input wires, while observing instrument performance to see if an intermittent open circuit can be located. Also check the primary element and associated external wiring for an open circuit. Check for transient stray signals which may exceed the instrument specifications.

(2) Check all connections to the amplifier and power assembly circuits, the measuring circuit, constant voltage circuit, chassis terminal block, chassis connector, and slidewire assembly.

(3) Check the slidewire contactor for excessive wear, poor tension, or misalignment. Check the slidewire for dirt or wear.

d. INSTRUMENT IS INSENSITIVE

(1) Check amplifier gain setting.

(2) Check shield connections and reference wiring (if applicable).

(3) Verify that stray level does not exceed instrument rating.

(4) Make sure gearing and cabling of balance system are free to move.

(5) Check amplifier by substitution if a spare is available.

e. CALIBRATION SHIFT

(1) Make sure the settings of the zero or span adjustors have not been changed.

(2) Check stray level.

(3) Check output of constant voltage circuit.

(4) Check measuring circuit by substitution if a spare, calibrated for the particular instrument, is available.

(5) Check that drive cable is securely attached to the indicator-carriage assembly.

1. DRIVE CABLE

a. REMOVAL

(1) Open the instrument door (or remove it).

(2) Raise the chassis release bar and slide the chassis forward to its first stop. Turn the rebalancing drive gear until the indicator carriage is at its lower (left hand) limit of travel.

(3) Loosen retaining screws, on the chassis dust cover, and swing cover up to gain access to the cabling system.

(4) Loosen retaining screws on the indicator carriage and free the cable from this assembly. If the instrument has an auxiliary drive shaft assembly, free the cable from the driven cable drum (loosen retaining screws in cable clamp).

(5) Unhook the spring-loaded end of the drive cable and pass the cable around the guide pulleys (figure 1).

(6) Slip the other end of the cable off the raised metal hook on the cable drum. Remove the cable carefully; avoid kinking.

b. INSTALLATION

(1) Turn cable drum clockwise until drive gear hits limit stop. Install drive cable as shown in figure 1, but note the following exceptions:

(a) On instruments with an auxiliary drive shaft assembly (for auxiliary alarm or control features), wrap the drive cable around the driven cable drum (1 turn). Clamp the cable to the drum after aligning the auxiliary system as specified later in this manual.

(b) On two-pen instruments the drive cable for lower pen servo (red pen) passes around four guide pulleys. Upper pen servo (purple pen) requires the free end of the cable (step C) to pass in front of the cable strand going to the right hand pulley.

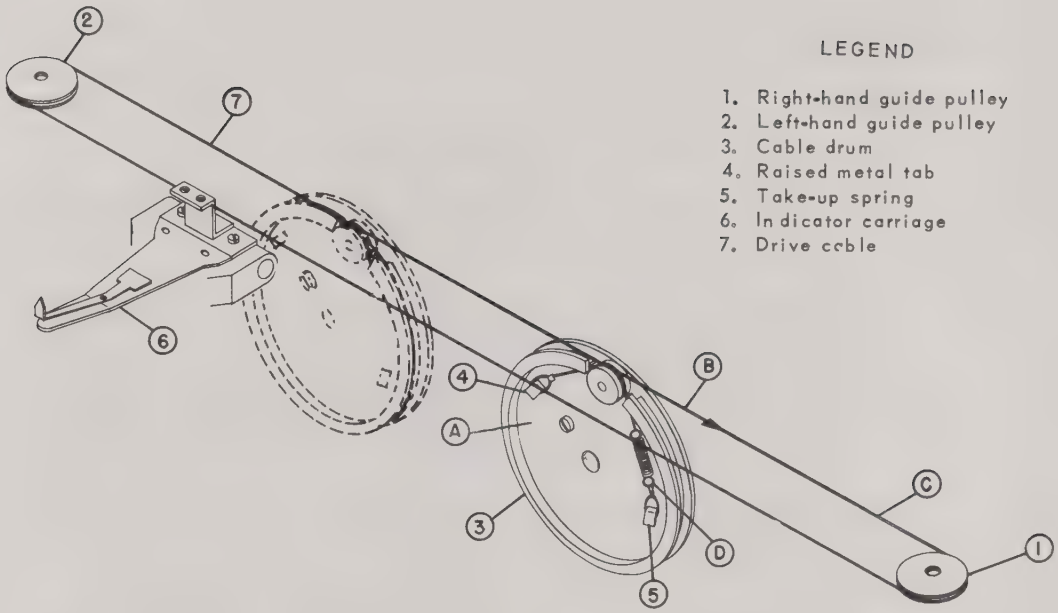
(2) Set the indicator carriage to its lower limit of travel, place the cable within the clamp, and tighten the retaining screw.

(3) Before placing the instrument back in service, check alignment of pointer and scale at both ends of travel and readjust if necessary.

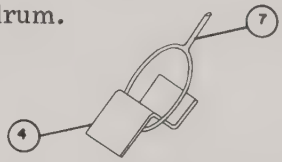
2. ALIGNMENT

a. CHECK

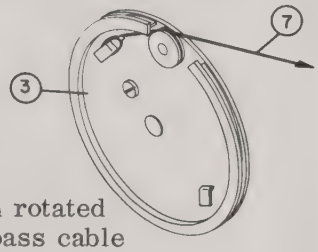
(1) Check alignment of indication system and adjust (if necessary) at the side of the chart which has round holes. The following steps assume that the round holes are on the right-hand side of the chart, and the elongated holes (for humidity compensation) are on the left.



A Place one end of drive cable (large loop) over the raised metal hook on the cable drum.

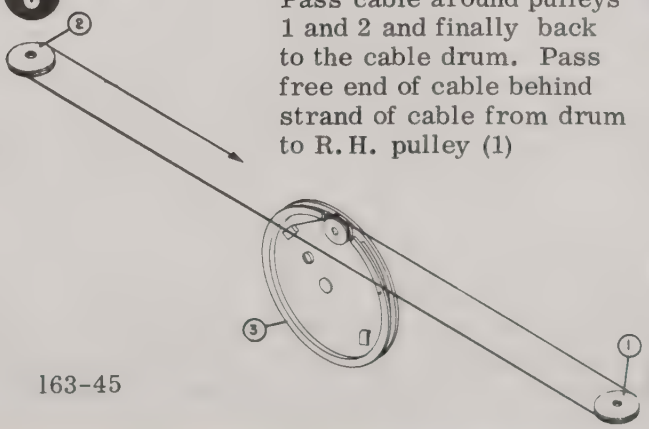


B



With cable drum rotated full clockwise, pass cable from top of drum to R.H. guide pulley (1).

C Pass cable around pulleys 1 and 2 and finally back to the cable drum. Pass free end of cable behind strand of cable from drum to R.H. pulley (1)



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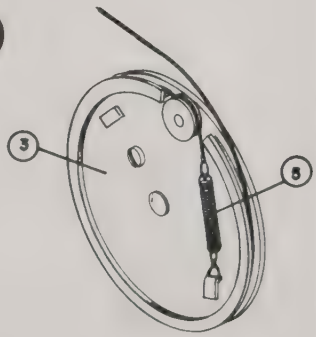
D



Pass cable once around the drum and hook the free end (small loop) to the tension take-up spring.

Figure 1. Drive Cable Installation

1. DRIVE CABLE

a. REMOVAL

(1) Open the instrument door (or remove it).

(2) Raise the chassis release bar and slide the chassis forward to its first stop. Turn the rebalancing drive gear until the indicator carriage is at its lower (left hand) limit of travel.

(3) Loosen retaining screws, on the chassis dust cover, and swing cover up to gain access to the cabling system.

(4) Loosen retaining screws on the indicator carriage and free the cable from this assembly. If the instrument has an auxiliary drive shaft assembly, free the cable from the driven cable drum (loosen retaining screws in cable clamp).

(5) Unhook the spring-loaded end of the drive cable and pass the cable around the guide pulleys (figure 1).

(6) Slip the other end of the cable off the raised metal hook on the cable drum. Remove the cable carefully; avoid kinking.

b. INSTALLATION

(1) Turn cable drum clockwise until drive gear hits limit stop. Install drive cable as shown in figure 1, but note the following exceptions:

(a) On instruments with an auxiliary drive shaft assembly (for auxiliary alarm or control features), wrap the drive cable around the driven cable drum (1 turn). Clamp the cable to the drum after aligning the auxiliary system as specified later in this manual.

(b) On two-pen instruments the drive cable for lower pen servo (red pen) passes around four guide pulleys. Upper pen servo (purple pen) requires the free end of the cable (step C) to pass in front of the cable strand going to the right hand pulley.

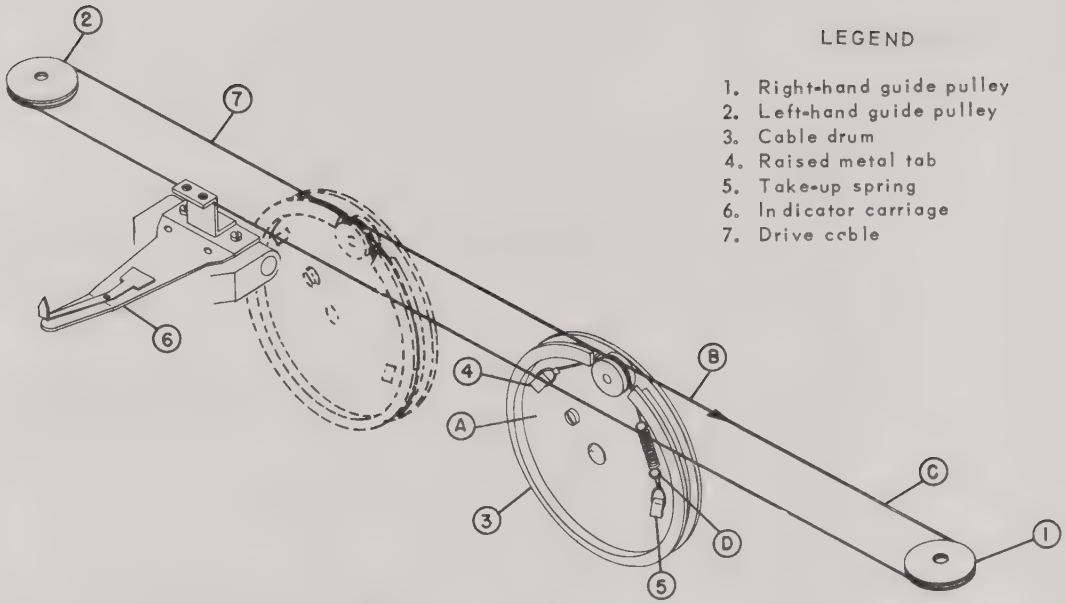
(2) Set the indicator carriage to its lower limit of travel, place the cable within the clamp, and tighten the retaining screw.

(3) Before placing the instrument back in service, check alignment of pointer and scale at both ends of travel and readjust if necessary.

2. ALIGNMENT

a. CHECK

(1) Check alignment of indication system and adjust (if necessary) at the side of the chart which has round holes. The following steps assume that the round holes are on the right-hand side of the chart, and the elongated holes (for humidity compensation) are on the left.



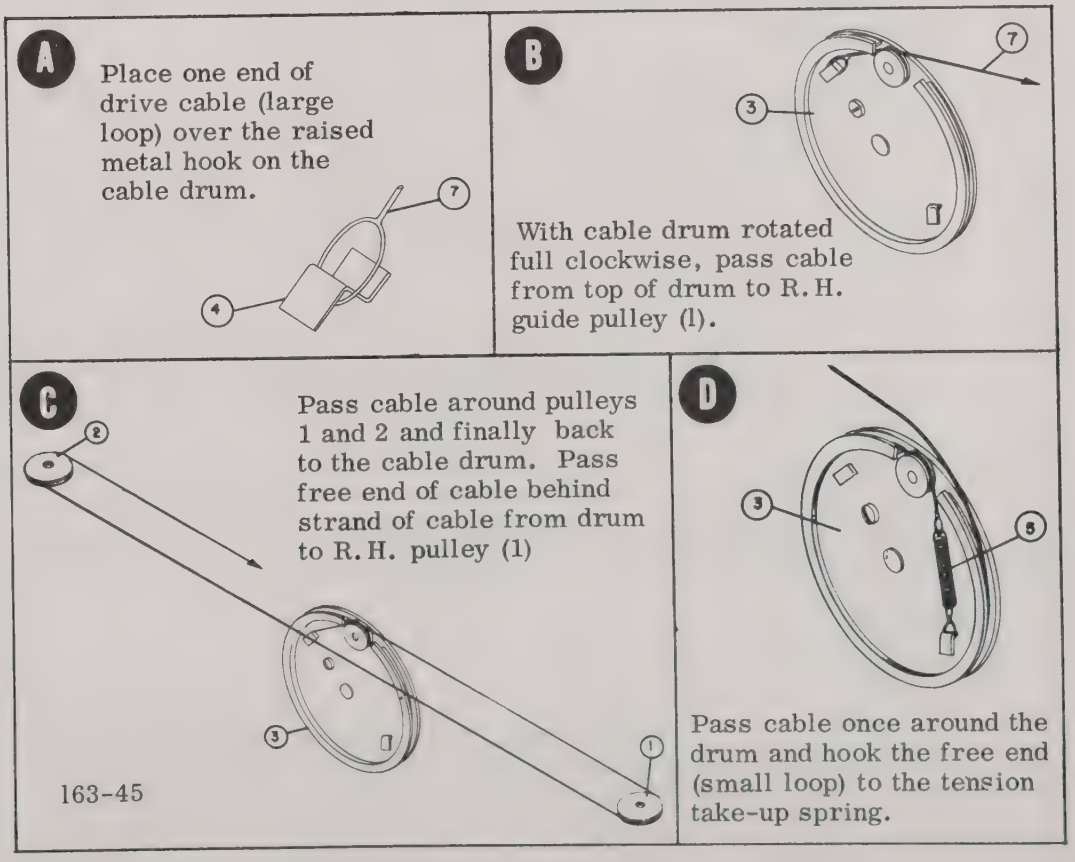

A
Place one end of drive cable (large loop) over the raised metal hook on the cable drum.
B
With cable drum rotated full clockwise, pass cable from top of drum to R.H. guide pulley (1).
C
Pass cable around pulleys 1 and 2 and finally back to the cable drum. Pass free end of cable behind strand of cable from drum to R.H. pulley (1)
D
Pass cable once around the drum and hook the free end (small loop) to the tension take-up spring.
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Figure 1. Drive Cable Installation

(2) With chart installed, manually move the indicator carriage (turn drive gear) to the right until the indicator points to the extreme right-hand scale graduation, or to another appropriate graduation (near the right-hand end of the scale) if the instrument is equipped with a right-hand event marker pen.

(3) On single-record instruments, pen tip should coincide with appropriate chart graduation. On multirecord instruments, vertical line of + symbol should print on appropriate chart graduation.

(4) On two-pen instruments, repeat the alignment check on the second pen system.

b. CARRIAGE Align indicator carriage with respect to chart as follows:

(1) Loosen retaining screws on chassis dust cover and swing cover up to gain access to the indicator carriage.

(2) Loosen the carriage cable clamp and reposition indicator carriage as required to align the recording device with the appropriate chart graduation.

(3) Be sure cable is in slot of cable clamp, tighten clamp and close dust cover.

(4) On two-pen instruments, repeat carriage alignment, if necessary, for the second pen.

c. SCALE Align scale with indicator carriage as follows:

(1) Move indicator carriage to line up recording device and extreme right-hand chart graduation.

(2) Loosen screws which secure scale and shift scale until appropriate graduation lines up with pointer; tighten screws.

(3) Move indicator carriage to line up recording device and extreme left-hand chart graduation. Appropriate scale graduation should line up with pointer within 0.01 inch.

(4) On two-pen instruments repeat the alignment procedure for the second pen system.

3. ADJUSTMENT OF DESENSITIZING SWITCHES

When desensitizing switches are supplied, adjust as follows (Fig. 2).

a. SINGLE PEN RECORDER.

(1) Position switch bracket (7) on right hand side plate so that roller on switch actuator (9) rests against rear flange of cable drum (3). Roller should overhang rear edge of cable drum about 1/16-inch.

(2) Manually turn cable drum (3) to position pen at right hand stop, then move it back about 1 to 2%.

LEGEND

1. Desensitizing switch (purple pen)
2. Cam plate
3. Cable drum
4. Actuating cam (left-hand limit)
5. Cam adjusting screws
6. Actuating cam (right-hand limit)
7. Switch bracket
8. Desensitizing switch (red pen)
9. Switch actuator

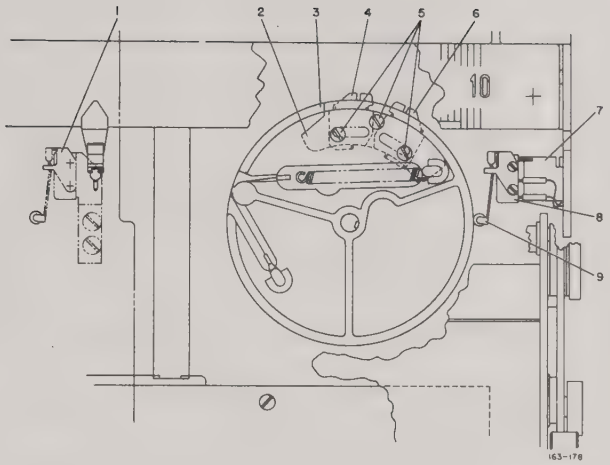

Figure 2. Desensitizing Switches

(3) Loosen three screws (5) and slide cam (6) along edge of drum until switch (8) just actuates, then tighten screw which holds cam (6) to cable drum.

(4) Turn cable drum until pen is 1 to 2% from left hand stop. Adjust cam (4) until switch just actuates, then tighten remaining two screws in cable drum.

(5) Rotate cable drum through full travel and check that switch is actuated within 1 to 2% of the stop at each end of scale.

b. TWO PEN RECORDER. Adjust desensitizing switches for both red and purple pen as described above.

CALIBRATION PREPARATION — SERVICE

1. PREPARATION PROCEDURE

a. Remove steel cover from rear of instrument case so connection terminals are accessible.

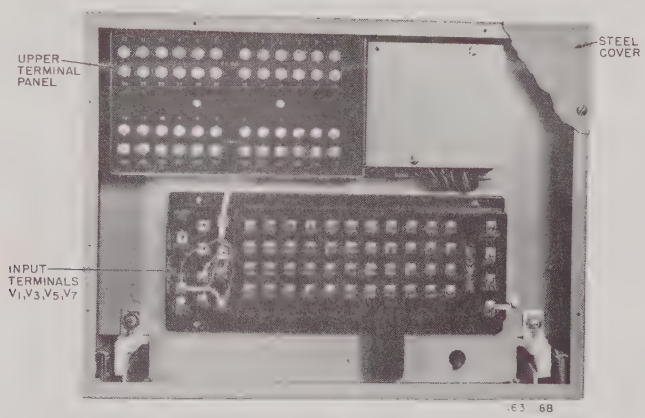

Figure 1. Rear of Typical Case (multipoint)

b. Remove input conductors from terminals V_1, V_3, V_5, and V_7. (On Multipoint with thermocouple actuation, remove an input from Upper Terminal Panel).

c. Connect a calibration cable to instrument input terminals.

CAUTION: Before touching any instrument connections, be sure no dangerous stray voltages exist.

d. Reinstall instrument cover plate. Take care not to pinch and short calibration cable against instrument case. It is essential to replace this cover for maximum calibration accuracy, especially on instruments with thermocouple actuation.

e. Where it is inconvenient to run calibration cable from rear of the instrument, the cable can be brought through instrument to the front as shown in Fig. 2.

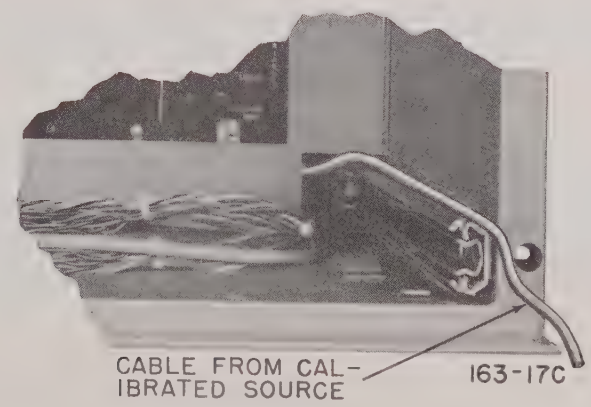

Figure 2. Calibration cable routing to the front

2. CALIBRATION CABLE

a. Usually a twisted pair of copper wires is all that is needed, except for thermometer and resistance thermometer actuations.

b. Narrow span millivolt actuations may require a shielded cable. Only cables having copper inner and shield conductors are acceptable.

c. Instruments with thermocouple actuations can be calibrated by two techniques, as described in Calibration Methods. When ice bath method is used, calibration cable is made from the thermocouple wire type for which actuation is designed (such as iron constantan, copper constantan, etc). Otherwise, use a twisted pair of copper wires.

d. Never use clips or lugs for connecting calibration cable. Connect only bared cable conductors.

3. CONNECTION POINTS

a. MILLIVOLT, RADIAMATIC,RESISTANCE THERMOMETER, D-C VOLTS, AND D-C CURRENT ACTUATIONS.

(1) Single pen and multipoint: Connect to points V_1 and V_3

(2) Two pen: Connect 2nd pen to points V_5 and V_7

(3) Shields: If the jumper buss originally supplied with the instrument has been removed, connect shield 1 to V_3 (shield 2 to V_7).

(4) On multipoint instruments calibration is made easier if print mechanism is stopped. If your instrument has no switch (option), this can be done by removing one of the gears in print motor gear train (retained by thumbscrew or split cotter).

b. THERMOCOUPLE ACTUATIONS

(1) One and two pen: connected same as with millivolt. Terminals, however, are on a small compensator block at the same location.

(2) Multipoint: connect to plus and minus terminals of that number on upper terminal panel which corresponds to the record number on print wheel. Regardless of actual character indicated (if other than a numeral), the character adjacent to large dot on indicator wheel is in position of terminal nine (9).

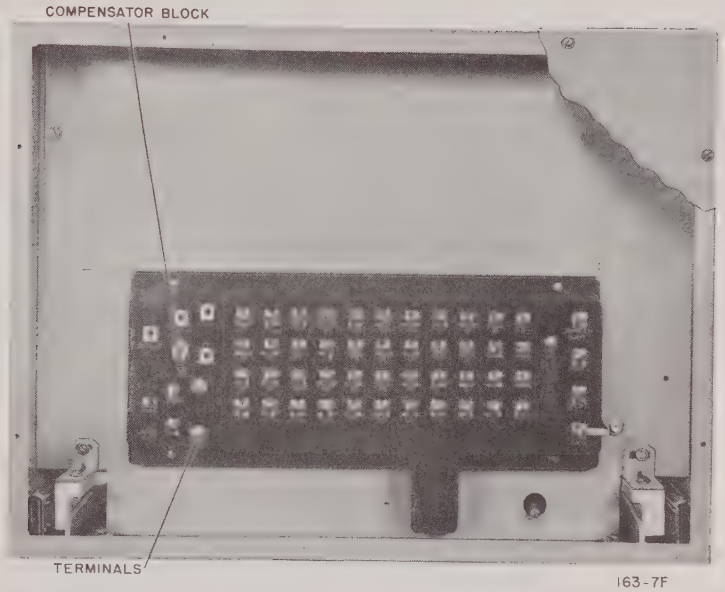

Figure 3. Rear of Typical Single Pen Case with Thermocouple Actuation

4. CALIBRATION METHODS

a. MILLIVOLT, RADIAMATIC, AND OTHER UNCOMPENSATED ACTUATIONS.

(1) Connect a precision voltage source (such as Honeywell Series 2700 or equivalent) to input terminals.

(2) Connect positive conductor to V_1 (V_5 on two pen), the negative to V_3 (V_7 on two pen).

b. RESISTANCE THERMOMETER ACTUATION

(1) Resistances of the wires usually affect the instrument reading. The instrument is best calibrated in its installation and by using a precision resistance decade box in place of the thermometer, at the thermometer location.

(2) Where instrument is not calibrated in its location, the calibration circuit should simulate resistances of wires and circuit of intended instrument installation. Typical circuits are given in the section on Measuring Circuit Theory (see table of contents).

c. D-C VOLTS OR D-C CURRENT ACTUATION.

(1) Use suitably calibrated d-c source to drive pen or indicator to required scalar positions. Follow a method similar to that outlined for millivolt actuations.

(2) If a voltage greater than 300 volts (dc) is applied to instrument, the 1.5 megohm current limiting resistor at terminal panel must be changed to limit current drawn from shield to a maximum value of 0.2 milliamperes. A shock hazard to personnel would otherwise exist.

d. **THERMOCOUPLE ACTUATION.** Two alternate methods of calibration may be used for instruments with thermocouple actuation. Highest accuracy will be obtained if a precision voltage source is used in conjunction with an icebath; however, reasonable accuracy can be obtained without the icebath. The input voltages used in the calibration procedure must be determined from a table of temperature-emf equivalents* (reference 0° C or 32° F) for the specific type of thermocouple employed.

(1) Reference Temperature - 0° C (32° F)

(a) Connect conductors from precision voltage source to a pair of compensated wires (thermocouple extension wire) for the particular thermocouple actuation, such as copper constantan, etc. Observe proper polarity.

(b) Connect the compensated wires to the instrument input terminals. Observe proper polarity (red thermocouple wire is negative).

(c) Immerse each junction of a copper lead and an extension wire in a melting ice bath; keep the junctions electrically insulated from each other and from the bath. Allow the junctions to stabilize at 0° C (32° F). Stir bath to obtain highest accuracy.

(d) Determine input voltages directly from a table of temperature -emf equivalents (reference 0°C or 32°F) for the specific type of thermocouple.

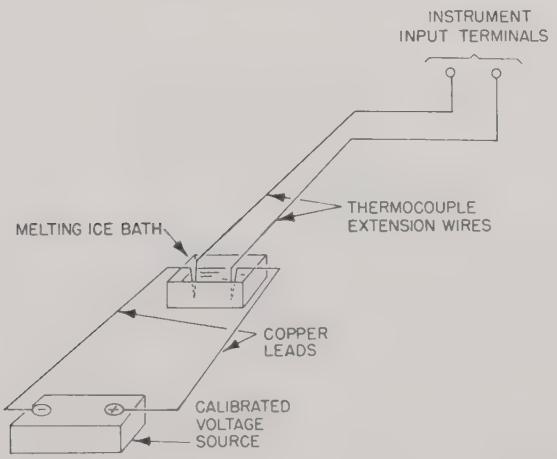

Figure 4. Test Connections for Ice Bath

(2) Reference Temperature - Ambient

(a) Connect conductors of precision voltage source directly to instrument input terminals. Observe proper polarity.

(b) Use a mercury thermometer to determine temperature at reference junction in instrument. (Access hole is provided in terminal cover.)

NOTE: Never close instrument chassis while thermometer is inserted in reference junction access hole.

(c) Determine input voltages by algebraic addition of emf equivalents for reference junction termperature with those for required scale readings.

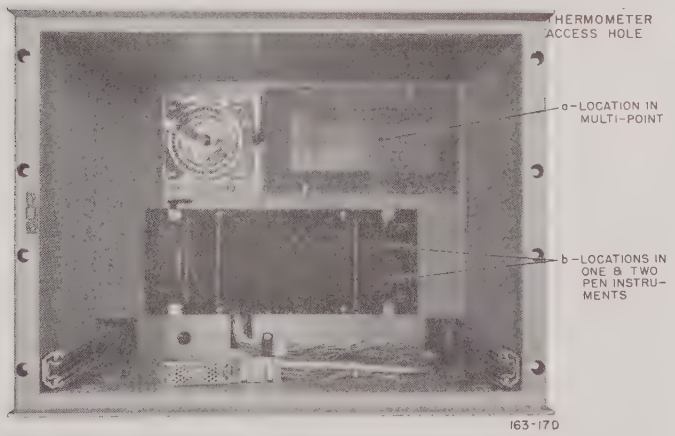

Figure 5. Typical Case Interior

(3) If a Honeywell Model 2720 is used as voltage source, temperature e.m.f. equivalent of the reference junction temperature should be determined. The Model 2720 should then be compensated for this value. All subsequent values may be read directly without necessity of subtracting equivalent emf for reference temperature from each value obtained.

5. IDEAL SITUATION

a. Ambient temperature during calibration should be close to ambient temperature during operation. Instrument internal temperature should be stabilized before calibration. Allow a 30 minute warm up (for greatest accuracy, on compensation actuations, allow instrument to warm up for two hours).

b. If internal temperature is disturbed when making electrical adjustments or when checking reference temperature with a mercury thermometer, internal temperature should be permitted to restabilize for 30 minutes.

1. AMPLIFIER GAIN (SENSITIVITY)

a. Switch on power. Permit normal instrument warmup.

b. Apply an input potential to drive indicator to mid-scale position.

c. Manually turn drive gear from side of chassis to move indicator upscale more than 1% full scale. Allow indicator to balance on its own and note this position.

d. Manually turn drive gear to move indicator downscale more than 1% full scale. Again, allow indicator to balance and note balance position.

e. If the difference in indicator positions exceeds the instrument deadband rating, increase instrument sensitivity by clockwise rotation of the gain adjustor (right-hand side of instrument chassis). If motor oscillation occurs, reduce gain slightly. Deadband is generally 0.1% of full scale, but check the Description section of this manual for the specifications of your particular instrument.

f. Repeat steps c, d, and e until difference in indicator positions (deadband) is within instrument specifications.

2. DAMPING

a. Set the indicator at mid-scale and apply a step change of at least 10% full scale.

b. Set the damping adjustment, (right-hand side of instrument chassis) for instrument balance in shortest time without excessive overshooting of balance position. Turn adjustor clockwise to reduce overshoot, counterclockwise to reduce damping action.

3. ZERO

a. General. Set voltage source to emf equivalent for major graduation nearest 10% full scale. If instrument does not balance at selected point, adjust zero.

If instrument reading is too high or too low, turn adjustor clockwise or counterclockwise respectively.

4. SPAN

a. After zero has been adjusted, set voltage source to emf equivalent for major graduation nearest 90% full scale.

b. If instrument does not balance at selected point, use adjustor on instrument chassis to correct instrument span. Check calibration at several other major graduations.

c. If necessary, repeat zero and span adjustments until calibration is satisfactory.

MEASURING CIRCUIT SERVICE

1. RANGE CHANGE

You can change instrument range by replacing the entire range card. Although service replacements are precalibrated units, minor zero and span adjustments may be required.

2. RESISTOR CALCULATIONS

This paragraph describes how the resistor values for the measuring circuit are calculated according to the range, span and type of primary element. This information is included to supplement the measuring circuit schematic diagram which does not specify any resistance values because of the many ranges available.

a. NOMENCLATURE

I_1 = The current through the upper branch of the measuring circuit, the current through R_1, R_2 and span network.

I_2 = The current through the lower branch of the measuring circuit. On millivolt and Radiamatic* unit actuations it's the current through R4 & R3

Ic = The current, on thermocouple actuations, through Rrj at 87.5°F (See Table I).

Rrj = The effective resistance of the reference junction compensation resistor assembly at 87.5°F (applies to thermocouple actuation only).

MVc = Millivoltage across Rrj at 32°F (0°C); applies to thermocouple actuation only (See Table I).

MV min = Millivoltage corresponding to 0% full scale; on the thermocouple actuations it's based on a reference junction at 0°C. MV min is often expressed as MV suppression or the displacement of 0 MV position from 0% full scale.

MV max = Millivoltage corresponding to 100% full scale; on thermocouple actuations it's based on a reference junction at 0°C.

MVs = Millivolt span (MV max - MV min).

Table I

T/C	I_c (ma)	MV_c
T	1.0934	9.7058
J	1.3797	12.2187
K	1.0768	9.5350
R	0.1610	1.4330
S	0.1610	1.4320

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b. FORMULAE

(1) Millivolt Actuation

(a) For spans less than 51 mv with suppression less than 30.88% of span:

$$R_1 = 500 - \frac{(317.5)\ (R5)}{317.5 + R5}$$

$$R_2 = 0$$

$$R_3 = 1000 - R_4$$

$$R_4 = (0.1544)\ (MV_s) - (0.5)\ (MV\ min)$$

$$R_5 = \frac{(317.5)\ (MV_s)}{60.240 - MV_s}$$

$$R_8 = 0$$

(b) For spans less than 51 MV with suppression greater than 30.88% of span:

$$R_1 = 500 - \frac{(317.5)\ (R_5)}{317.5 + R_5} - R_2$$

$$R_2 = (0.25)\ (MV_{min}) - (.0772)\ (MV_s)$$

$$R_3 = 1000$$

$$R_4 = 0$$

$$R_5 = \frac{(317.5)\ (MV_s)}{60.240 - MV_s}$$

$$R_8 = 0$$

(c) For spans greater than 51 MV with suppression less than 24.75% of span.

$$R_1 = 363.64 - \frac{(317.5)\ (R_5)}{317.5 + R_5}$$

$$R_2 = 0$$

$$R_3 = 4000 - R_4$$

$$R_4 = (0.5150)\ (MV_s) - (2.0)\ (MV_{min})$$

$$R_5 = \frac{(317.5)\ (MV_s)}{100 - MV_s}$$

$$R_8 = 1127$$

(d) For spans greater than 51 MV with suppression greater than 24.75% of span

$$R_1 = 363.64 - \frac{(317.5)\ (R_5)}{317.5 + R_5} - R_2$$

$$R_2 = (0.1818)\,(MV_{min}) - (.04682)\ (MV_s)$$

$$R_3 = 4000$$

$$R_4 = 0$$

$$R_5 = \frac{(317.5)\ (MV_s)}{100 - MV_s}$$

$$R_8 = 1127$$

(2) Thermocouple Actuation

(a) Spans up to 70 millivolts

(1) When MVc (Table 1) is greater than 30.88% of span:

$$R_1 = \frac{2000}{I_1} - \frac{(317.5)\ (R_5)}{317.5 + R_5} - R_2$$

$$R_2 = \frac{1}{I_1}\left[MV_{min} + MVc - (0.3088)\ (MV_s)\right]$$

$$R_3 = \frac{2000}{I_2} - 10$$

$$R_4 = 0$$

$$R_5 = \frac{(317.5)\ (MV_s)}{(I_1)\ (15.06) - MV_s}$$

$$R_8 = 0$$

(2) When MVc is less than 30.88% of span:

$$R_1 = \frac{2000}{I_1} - \frac{(317.5)\ (R_5)}{317.5 + R_5}$$

$$R_2 = 0$$

$$R_3 = \frac{2000}{I_2} - R_4 - 10$$

$$R_4 = \frac{1}{I_2}\left[-MV_{min} - MVc + (0.3088)\ (MV_s)\right]$$

$$R_5 = \frac{(317.5)\ (MV_s)}{(I_1)\ (15.06)\ -MV_s}$$

$$R_8 = 0$$

(b) Spans 70 to 100 millivolts

(1) When $MVc + MV_{min}$ is greater than 20.82% of span:

$$R_1 = \frac{2000}{I_1} - \frac{(317.5)\ (R_5)}{317.5 + R_5} - R_2$$

$$R_2 = \frac{1}{I_1}\left[MV_{min} + MVc - (0.2082)\ (MV_s)\right]$$

$$R_3 = \frac{2000}{I_2} - 10$$

$$R_4 = 0$$

$$R_5 = \frac{(317.5)\ (MV_s)}{(I_1)\ (22.698) - MV_s}$$

$$R_8 = 2187.5$$

(2) When $MVc + MV_{min}$ is less than 20.82% of span:

$$R_1 = \frac{2000}{I_1} - \frac{(317.5)\ (R_5)}{317.5 + R_5}$$

$$R_2 = 0$$

$$R_3 = \frac{2000}{I_2} - R_4 = 10$$

$$R_4 = \frac{1}{I_2}\left[(0.2082)\ (MV_s) - MV_{min} - MVc\right]$$

$$R_5 = \frac{(317.5)\ (MV_s)}{(I_1)\ (22.698) - MV_s}$$

$$R_8 = 2187.5$$

(3) Radiamatic Unit

Use formulas for millivolt actuation. When calibrating rheostat is supplied the following resistors are added:

$$R_{11} = 4166$$

$$R_P = 5000$$

(4) DC Volts and Tachometer

(a) For positive suppression greater than 30.88% of span

$$R_1 = 447.3 - R_2$$

$$R_2 = (0.25)\left(\frac{R_{11}}{R_{11} + R_{12}}\right)(V_{min}) - 0.772$$

$$R_3 = 1000$$

$$R_4 = 0$$

$$R_5 = 63.19$$

(b) For positive suppression less than 30.88% of span or for negative suppression:

$$R_1 = 447.3$$

$$R_2 = 0$$

$$R_3 = 1000\text{-}R_4$$

$$R_4 = 1.544 - (.5)\left(\frac{R_{11}}{R_{11} + R_{12}}\right)(V_{min})$$

$$R_5 = 63.19$$

(c) Voltage Divider (R_{11} and R_{12})

(1) For spans greater than 1.0 volt

$$R_{11} = \frac{10,000}{V_s - .01}$$

$$R_{12} = 1,000,000$$

(2) For spans less than 1.0 volt

$$R_{11} = \frac{1000}{V_s - .01}$$

$$R_{12} = 100,000$$

(5) DC Current

(a) For positive suppression less than 30.88% of span; and for negative suppression.

$$R_1 = 500 - \frac{(317.5)(R_5)}{317.5 + R_5}$$

$$R_2 = 0$$

$$R_3 = 1000\text{-}R_4$$

$$R_4 = (R_{11})\left[(0.1544)\ (MA_s) - (0.5)\ (MA_{min})\right]$$

$$R_5 = \frac{(317.5)\ (MA_s)\ (R_{11})}{60.240 - (MA_s)\ R_{11}}$$

$$R_{11} = \frac{MV_s}{MA_s}$$

(b) For positive suppression greater than 30.88% of span:

$$R_1 = 500 - \frac{(317.5)\ (R_5)}{317.5 + R_5} - R_2$$

$$R_2 = R_{11}\left[(0.25)\ (MA_{min}) - (0.0772)\ (MA_s)\right]$$

$$R_3 = 1000$$

$$R_4 = 0$$

$$R_5 = \frac{(R_{11})\ (317.5)\ (MA_s)}{60.240\text{-}(MA_s)\ (R_{11})}$$

$$R_{11} = \frac{MVs}{MAs}$$

(6) Resistance Thermometer

(a) Circuit Parameters

I_3 = Current through Rx

Rx_{min} = bulb suppression in ohms

Rx_s = bulb span in ohms

$MV_{min} = I_3\ (Rx_{min})$

$MVs = I_3\ (Rx_s)$

(b) For spans of 1 to 10 ohms

$$R_1 = 4000 - \frac{(317.5)\ (R_5)}{(317.5) + R_5} - R_2$$

$$R_2 = 0.4\left[(MV_{min}) - (0.2988)\ (MV_s)\right]$$

$$R_3 = R_6 - Rx_{min} - (1/2)\ (Rx_s)$$

$$R_4 = 1992$$

$$R_5 = \frac{(20.219)\ (MV_s)}{2.5 - (0.0664)\ (MV_s)}$$

$$R_6 = 4000$$

$$R_7 = 4000$$

(c) For spans 10 to 100 ohms

$$R_1 = 4000 - \frac{(317.5)\ (R_5)}{317.5 + R_5} - R_2$$

$$R_2 = 0.4\left[(MV_{min}) - (0.2988)\ (MV_s)\right]$$

$$R_3 = 40,000$$

$$R_4 = 20,000$$

$$R_5 = \frac{(20.219)\ (MV_s)}{2.5 - (0.0664)\ (MV_s)}$$

$$R_6 = 40,000$$

$$R_7 = 4,000$$

(d) For spans of 100 to 1000 ohms

$$R_1 = 4000 - \frac{(317.5)\ (R_5)}{317.5 + R_5} - R_2$$

$$R_2 = 0.4\left[(MV_{min}) - (0.2988)\ (MV_s)\right]$$

$$R_3 = 400,000$$

$$R_4 = 200,000$$

$$R_5 = \frac{(20.219)\ (MV_s)}{2.5 - (0.0664)\ (MV_s)}$$

$$R_6 = 400,000$$

$$R_7 = 4000$$

CONSTANT VOLTAGE CIRCUIT — SERVICE

1. OUTPUT VOLTAGE CHECK

a. Switch off instrument power. Slide chassis out to first stop and lower chart carriage to gain access to the circuit unit. Remove the two screws and remove the servo circuit unit cover.

b. Break connections between the constant voltage circuit and the measuring circuit. Maintain connections to the power assembly unless an independent source of 47 V ac is available.

c. Construct a voltage divider network across the output terminals as shown in figure 1. Use decade boxes, if available, otherwise use a pair of manganin resistors, part number 76098-999-(resistance value) or their equivalent (±0.05% tolerance). Select resistor values of 333.33 ohms (R1) and 10 ohms (R2). The total resistance (343.33 ohms) is the recommended load for the constant voltage circuit. Selecting a 10 ohm resistor for R2 results in convenient and accurate measurement of its voltage drop (60 millivolts).

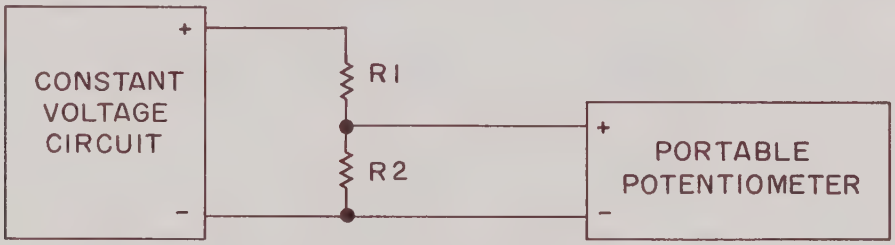


Figure 1. Constant Voltage Circuit Output Voltage Check 33-E-14-1

Table I

Constant Voltage Circuit	Freq. (CPS)	Current (ma)	Output (Volts)	Load (Ohms)	Dummy Load R1	Dummy Load R2	Voltage Across R2 (MV)
370751-1	60	6	2.060	343.33	333.33	10	60

d. Use a precision voltage source (Honeywell Series 2700 or equivalent) as a null indicating device to measure the voltage drop across R2. An error of more than 1 mv indicates the output voltage has shifted from the calibrated 2.060 volts; replace the constant voltage circuit.

2. TROUBLESHOOTING

a. GENERAL

(1) Avoid all field repairs to the constant voltage circuit; if possible replace the entire unit. However, if troubleshooting the circuit is the only means of placing critical equipment back in service, perform the voltage and resistance checks described in this section.

Servicing is limited because the matched circuit components cannot be replaced in the field.

(2) Component locations on the printed circuit board are shown in figure 2. Check points A, B, C, D, and E are identified physically in figure 3; they are also shown schematically in figure 4.

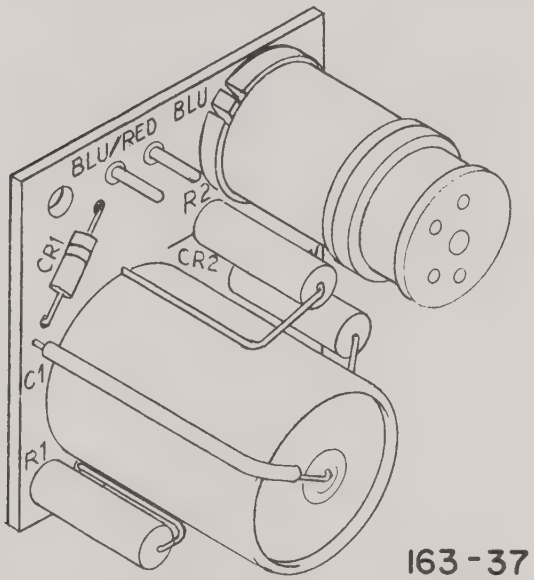


Figure 2. Constant Voltage Circuit Component Locations

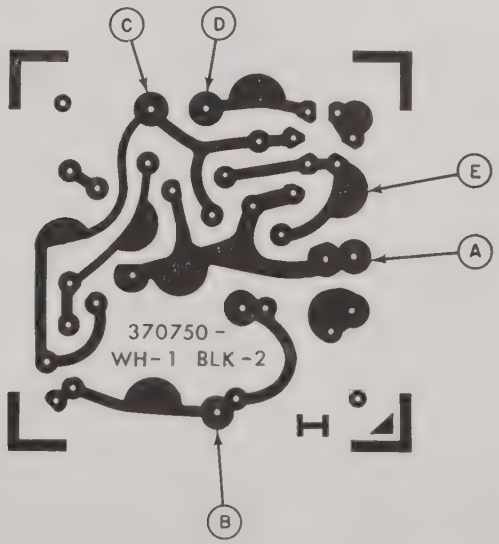


Figure 3. Constant Voltage Circuit Test Point Locations 163-36

CONSTANT VOLTAGE CIRCUIT

SERVICE

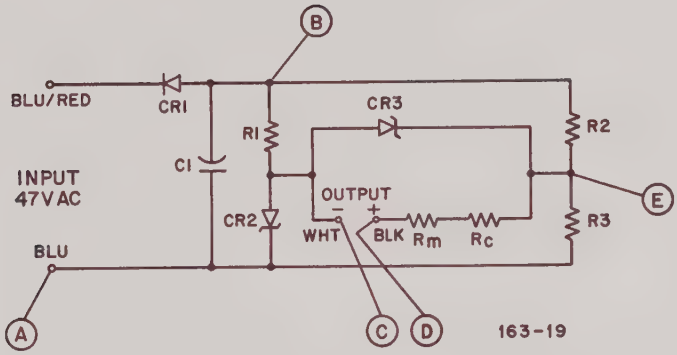


Figure 4. Constant Voltage Circuit Schematic Diagram

b. VOLTAGE CHECKS

(1) Use the same basic test set-up described for checking the output voltage, but loosen the mounting screws and flip the circuit board over to gain access to the printed wiring connections.

(2) Check voltages (per Table 2) from the output of the power supply secondary up to and including the second stage zener diode.

Table 2

C.V.C. Replacement	D.C. Volts between pts.						Component Values			
	A-B	C-B	A-C	A-E	E-B	D-C	R1	R2	R3	C1
370751-501	55	39	16	9.5	45.5	2.06	2100	29.4K	787Ω	100mfd

c. RESISTANCE CHECKS

(1) Switch off instrument power and remove the printed circuit board from the instrument.

(2) Discharge capacitor C1 before starting resistance checks.

(3) Use an ohmmeter to check for the resistance values shown in Table 2.

d. REPAIRS

(1) CR1, C1, R1, R2, and R3 may be replaced with equivalent parts, having the same tolerance as the original.

(2) If the defective component is CR2, CR3, Rc, or Rm, however, DO NOT attempt field repairs. The values of these components are critical to the accuracy of the constant voltage circuit.

CONSTANT VOLTAGE CIRCUIT

SERVICE

1. OUTPUT VOLTAGE CHECK

a. Switch off instrument power. Slide chassis out to first stop and lower chart carriage to gain access to circuit unit. Remove two screws and remove servo circuit unit cover.

b. Break connections between constant voltage circuit and measuring circuit. Maintain connections to power assembly unless an independent source of 120 vac is available.

c. Construct a voltage divider network across output terminals as shown in figure 1. Use decade boxes, if available, otherwise use a pair of manganin resistors, part number 76098-999-(resistance value) or their equivalent (±0.05% tolerance). Select resistor values of 333.33 ohms (R1) and 10 ohms (R2). The total resistance (343.33 ohms) is the recommended load for the constant voltage circuit. Selecting a 10 ohm resistor for R2 results in convenient and accurate measurement of its voltage drop (60 millivolts).

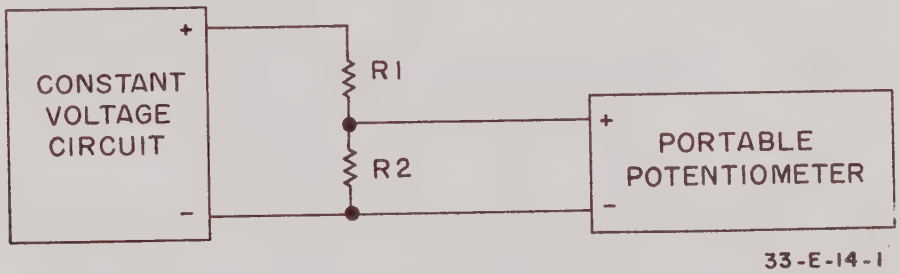


Figure 1. Constant Voltage Circuit Output Voltage Check.

TABLE I

Constant Voltage Circuit	Freq. (CPS)	Current (ma)	Output (Volts)	Load (Ohms)	Dummy Load		Voltage Across R2 (MV)
					R1	R2	
370751-1	60	6	2.060	343.33	333.33	10	60

d. Use a precision voltage source (Honeywell Series 2700 or equivalent) as a null indicating device to measure the voltage drop across R2. An error of more than 1 mv indicates the output voltage has shifted from the calibrated 2.060 volts; replace the constant voltage circuit.

2. TROUBLESHOOTING

a. GENERAL.

(1) Avoid all field repairs to the constant voltage circuit; if possible replace the entire unit. However, if troubleshooting the circuit is the only means of placing critical equipment back in service,

perform the voltage and resistance checks described in this section. Servicing is limited because the matched circuit components cannot be replaced in the field.

(2) Component locations on the printed circuit board are shown in figure 2. Check points A, B, C, D, and E are identified physically in figure 3; they are also shown schematically in figure 4.

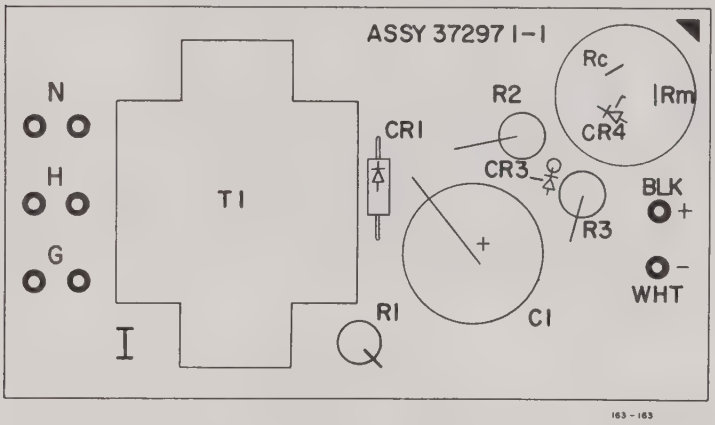


Figure 2. Constant Voltage Circuit Component Locations.

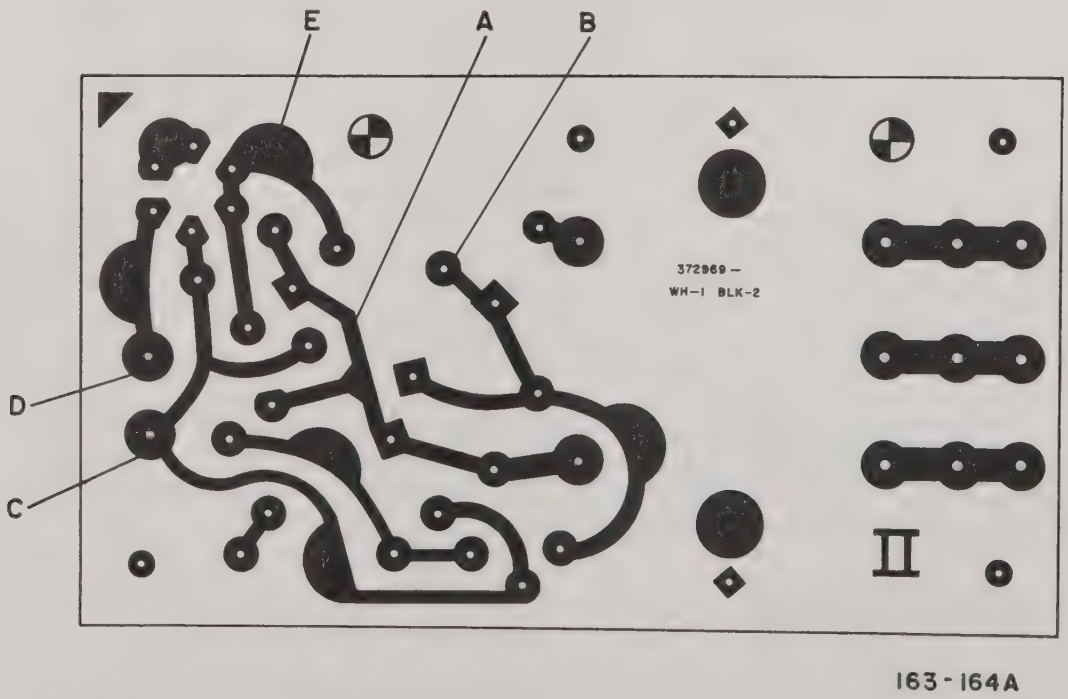


Figure 3. Constant Voltage Circuit Test Point Locations.

CONSTANT VOLTAGE UNIT

SERVICE

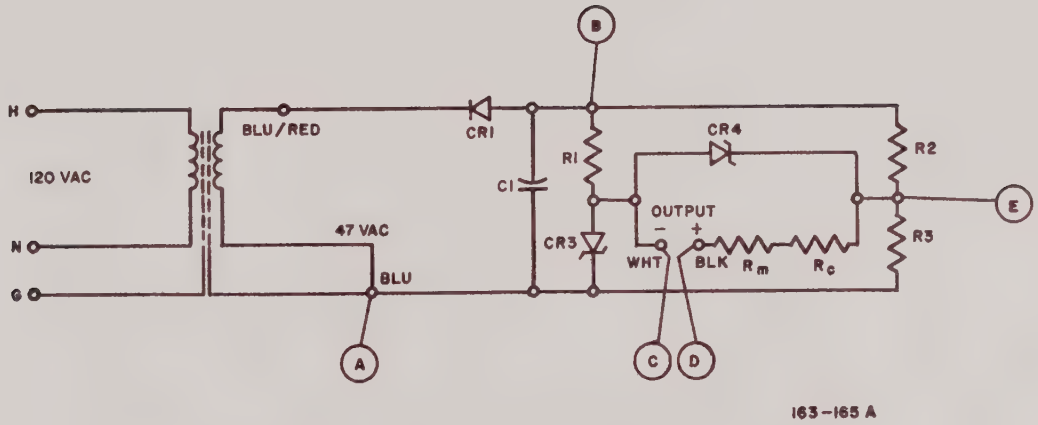


Figure 4. Constant Voltage Circuit Schematic Diagram.

b. VOLTAGE CHECKS

(1) Use same basic test set-up described for checking output voltage, but loosen mounting screws and flip circuit board over to gain access to printed wiring connections.

(2) Check voltages (per Table 2) from output of power supply secondary up to and including second stage zener diode.

TABLE 2

D. C. Volts between pts.							Component Values			
A-B	C-B	A-C	A-E	E-B	D-C	C-E	R1	R2	R3	C1
55	39	16	9.5	45.5	2.06	6.65	2100	29.4K	787	30mfd

c. RESISTANCE CHECKS

(1) Switch off instrument power and remove the printed circuit board from instrument.

(2) Discharge capacitor C1 before starting resistance checks.

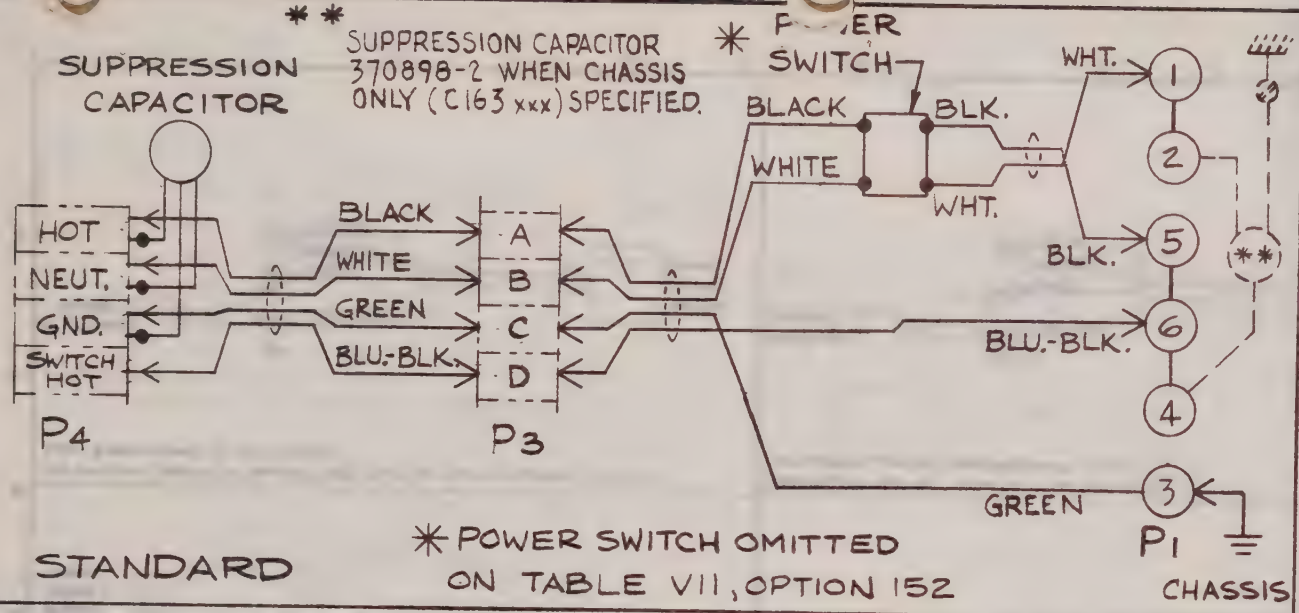
(3) Use an ohmmeter to check for resistance values shown in Table 2.

d. REPAIRS

(1) CR1, CR3, C1, R1, R2, and R3 may be replaced with equivalent parts, having the same tolerance as the original.

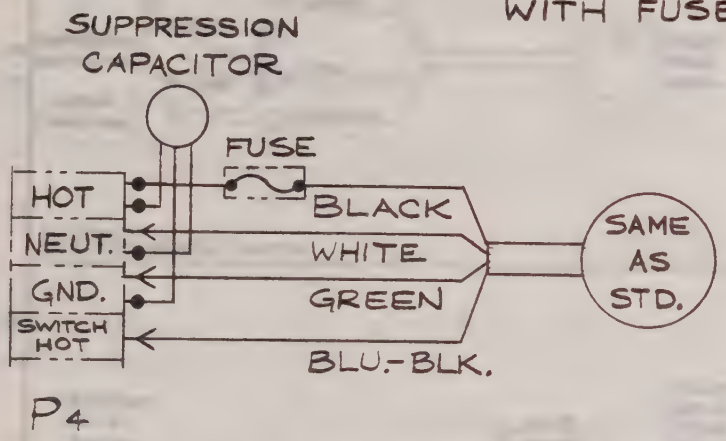
(2) If the defective component is CR4, Rc, or Rm, however, DO NOT attempt field repairs. The values of these components are critical to the accuracy of the constant voltage circuit.

REFERENCE DRAWINGS



a	b	c	d	e	f	g	h	i

ISS.	REVISION	APP.
1.	1-24-64 E07479-30P	JHM
2.	6-18-64 E07479-35P	DEJ
3.	P4 PLUG IN CONNECTIONS WERE SOLDERED 1-25-65 E.O. 7479-6R	HS
4.	ADDED SUPPRESSION CAP. AND NOTE **: TERMINAL 4 CHANGED TO HOT 2-24-65 EO 7479-7R	HS



REPRO. LOC.	
TORONTO	
NEWHSE.	
FALL RIV.	
GERMANY	
TOKYO	
AMIENS	
AUSTRALIA	

MATLS. —
IE JS 1-23
CHK. HM 1-22
JOB 7479
SCALE NONE

HONEYWELL MP
BROWN INSTRUMENTS DIVISION
PHILADELPHIA, PA., U.S.A.

WIRING DIAGRAM
120 VOLTS POWER CONNECTIONS

CL. 16 S.C.P

DRAWN	WCT 12-17-63	A SIZE	DRAWING NO. 372809
ENGR.	H MUSE 1-23-64		
SUPV.	JB 1-23		

3 CL

TOLERANCE UNLESS NOTED		
One Place	(.0)	± .030
Two Place	(.00)	± .015
Three Place	(.000)	± .005
Angular		± 1°

MATL.	USED ON
FIN.	REF.

FORM 3201 (REV. 3/63)

SUPPRESSION CAPACITOR
ONLY (C163 xxx) SPECIFIED.
SUPPRESSION CAPACITOR
STANDARD
ON TABLE VII, OPTION 1S2
POWER SWITCH OMITTED
WITH FUSE TABLE VII OPTION 3S
WIRING DIAGRAM
120 VOLTS POWER CONNECTIONS
HONEYWELL Inc.
BROWN INSTRUMENTS DIVISION
PHILADELPHIA, PA., U.S.A.
SWITCH
BLACK
WHITE
BLK
WHT
SW1
SW2
SW3
SW4
SW5
SW6
SW7
SW8
SW9
SW10
SW11
SW12
P1
P2
P3
P4
P5
P6
P7
P8
P9
P10
P11
P12
P13
P14
P15
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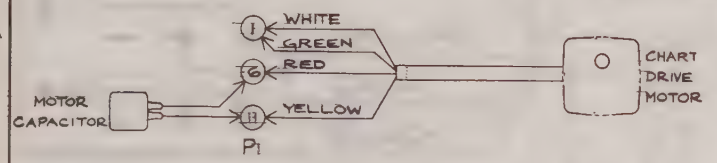
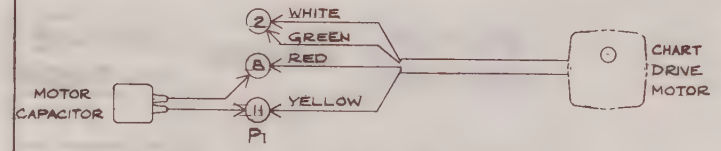
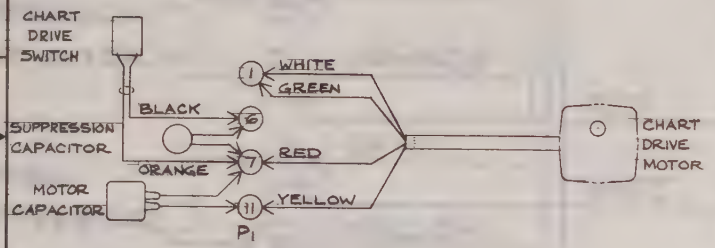
P95
P96
P97
P98
P99
P100



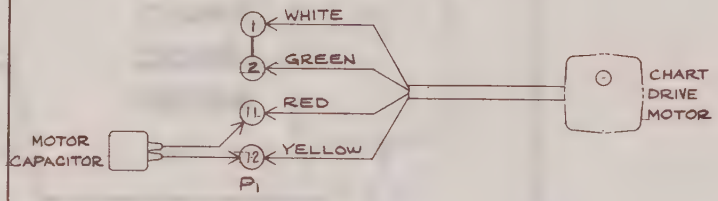
PEN RECORDING & MULTIPOINT
(NO SWITCH TABLE VII, OPTION 153) WITH OR WITHOUT OPTIONS 270 & 271



MULTIPOINT PRINT RECORDING WITH
(SELECT-O-PRINT TABLE VII, OPTION 271)

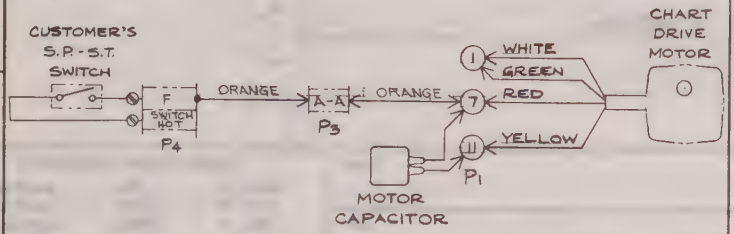


MULTIPOINT & PEN RECORDING - SWITCH



MULTIPOINT PRINT RECORDING - WITH
SELECT-O-PRINT TABLE VII OPTION 270

NOTE -
ALL HI SPEED MOTORS TURN CLOCKWISE
WHEN FACING PINION.



PEN RECORDING & MULTIPOINT
(REMOTE SWITCH TABLE VII, OPTION 155)

ISS.	REVISION	APP.
1.	1-24-64 E07479-30P	JWM.
2.	ADD. WORD "MULTIPOINT TO NOTES 6-18-64 E07479-35P	DEL
3	B-3) ADD. "WITH OR WITHOUT OPTIONS 270 & 271 E-162) P8, A-A WAS "D" P4, ADD SECTION "F" ORANGE WAS "BLUE-BLK 8-8-64 E07479-36P	JWM
4.	C-5) REVERSED RED & YEL. LEADS 11-5-64 E07479-48P	DEL

HONEYWELL
BROWN INSTRUMENTS DIVISION
PHILADELPHIA, PA., U.S.A.

MFG. LOC.: TORONTO, NEWHSE., FALL RIV., GERMANY, TOKYO, AMIENS, AUSTRALIA

MATLS. —
IE JS 1-23
CHK. HM 1-22
JOB 7479
SCALE NONE

WIRING DIAGRAM
HI SPEED CHART DRIVES

CL. 16 S.C.P.

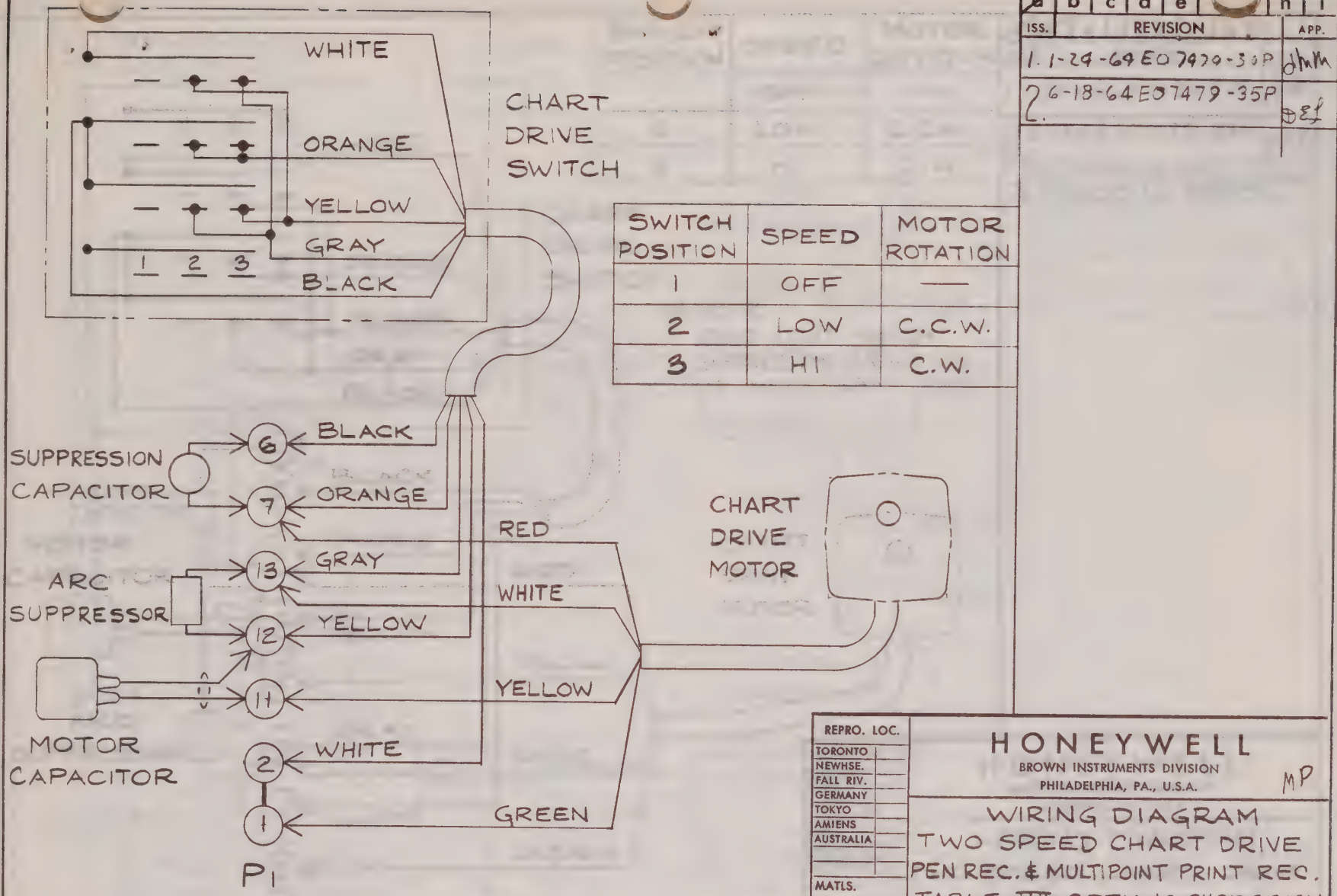
DRAWN	JEMBORN 12-19-1963	
ENGR.	MUSE 1-23-64	
SUPV.	J. BENARAS 1-27-64	

SIZE C

DRAWING NO. 372814

3 CL.

FORM 3313 (REV. 3/63)



SWITCH POSITION	SPEED	MOTOR ROTATION
1	OFF	—
2	LOW	C.C.W.
3	HI	C.W.

ISS.	REVISION	APP.
1.	1-29-64 EO 7470-30P	dhm
2.	6-18-64 EO 7479-35P	ef

REPRO. LOC.	
TORONTO	
NEWHSE.	
FALL RIV.	
GERMANY	
TOKYO	
AMIENS	
AUSTRALIA	
MATLS.	
IE	JS 1-23
CHK.	HM 1-23
JOB	7479
SCALE	NONE

HONEYWELL
BROWN INSTRUMENTS DIVISION
PHILADELPHIA, PA., U.S.A.
MP

WIRING DIAGRAM
TWO SPEED CHART DRIVE
PEN REC. & MULTIPOINT PRINT REC.
TABLE VII OPTIONS 211,212,213,&214
CL. 16 S.C.P.

DRAWN	WCT 12-13-63	A SIZE	DRAWING NO. 372815
ENGR.	MUSE 1-23		
SUPV.	JB 1-23		3 CL

TOLERANCE UNLESS NOTED		
One Place	(.0)	± .030
Two Place	(.00)	± .015
Three Place	(.000)	± .005
Angular		± 1°

MATL.
FIN.
USED ON
REF.

FORM 3201 (REV. 3/63)

HONEYWELL

BROWN INSTRUMENTS DIVISION
PHILADELPHIA, PA., U.S.A.

WIRING DIAGRAM
TWO SPEED CHART DRIVE
WITH OPTIONS SHOWN
SERIES VII TABLE

SWITCH POSITION	SWITCH	
OFF	—	
LOW	S	C.C.W.
HI	S	C.W.

CHART DRIVE SWITCH

CHART DRIVE MOTOR

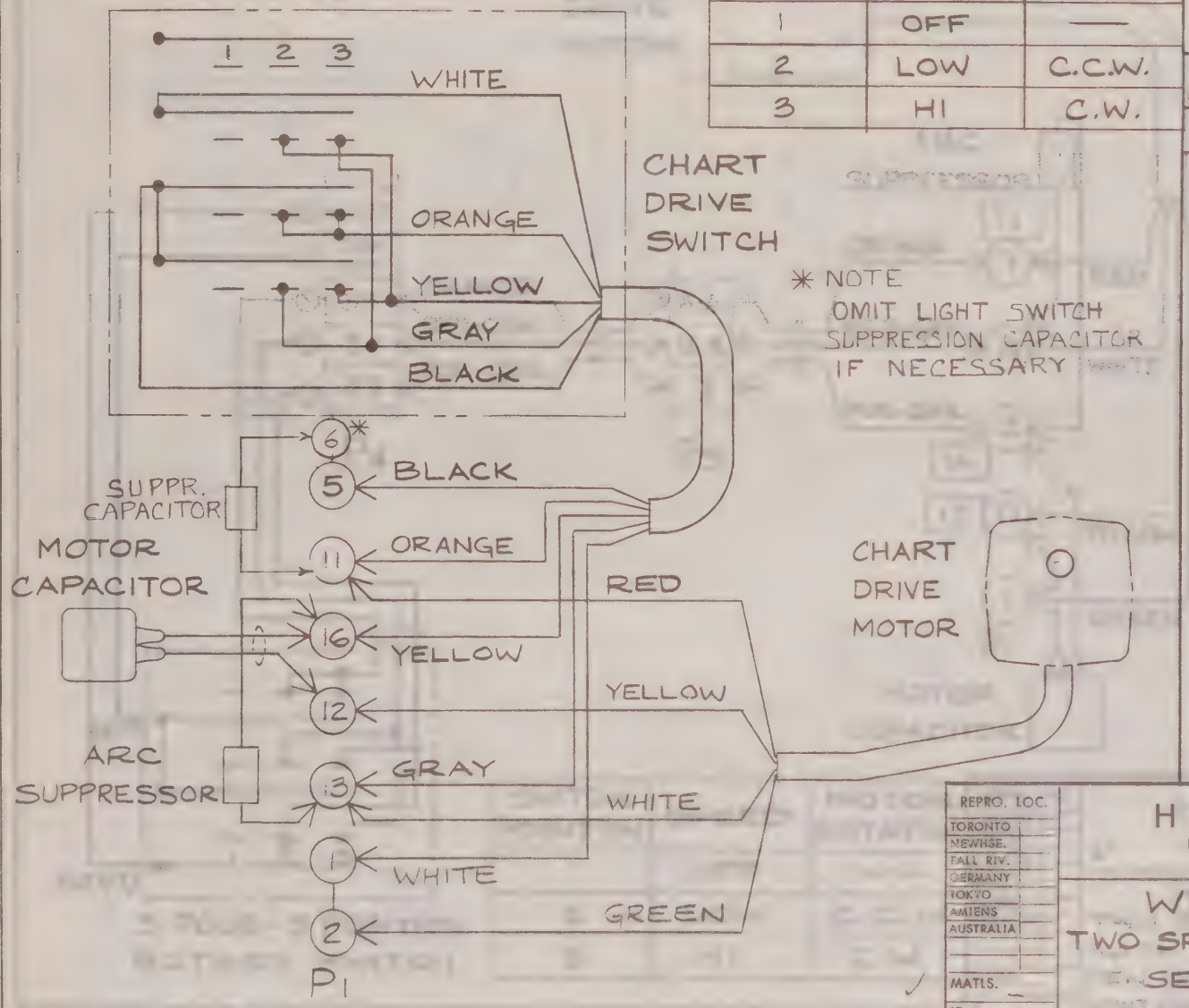
SUPPRESSION CAPACITOR

MOTOR CAPACITOR

ORANGE
YELLOW
GRAY
BLACK
BLACK
ORANGE
WHITE
RED
WHITE
BLACK

SWITCH POSITION	SPEED	MOTOR ROTATION
1	OFF	—
2	LOW	C.C.W.
3	HI	C.W.

ISS.	REVISION	APP.
1.	1-24-64 E07479-30P	JWM
2.	6-18-64 E07479-35P	DEJ
3	ADD SUPPR CAP & NOTE 12-30-64 E07479-2R	GJB



REPRO. LOC.
TORONTO
NEWHSE.
FALL RIV.
GERMANY
TOKYO
AMIENS
AUSTRALIA
MATLS.
IE JS 1-23
CHK. HM 1-27
JOB 7479
SCALE NONE

HONEYWELL
BROWN INSTRUMENTS DIVISION
PHILADELPHIA, PA., U.S.A.

WIRING DIAGRAM
TWO SPEED CHART DRIVE
SELECT-O-PRINT
CL. 16 S.C.P.

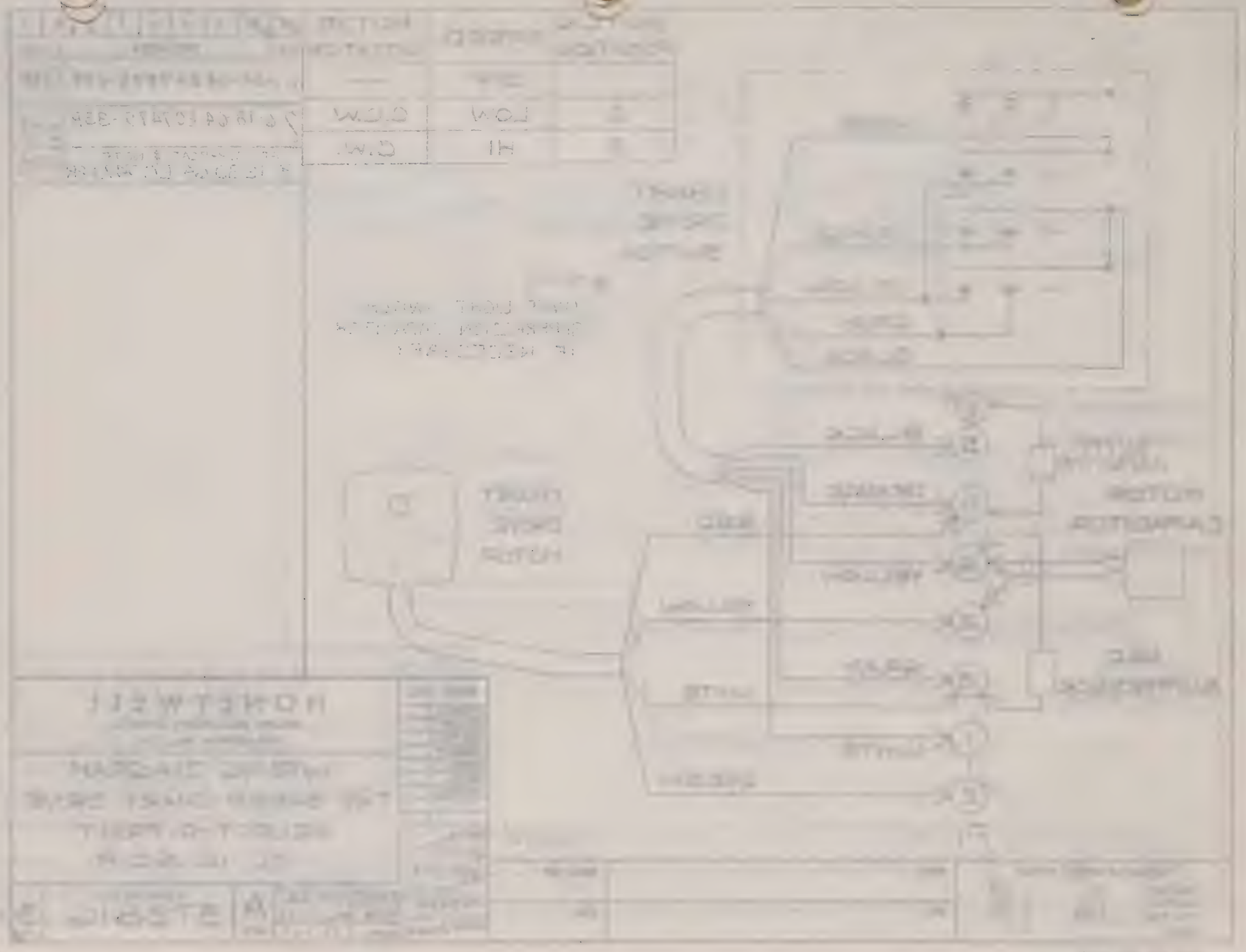
DRAWN	W.C.T. 12-13-63
ENGR.	MWE 1-23
SUPV.	JB 1-23

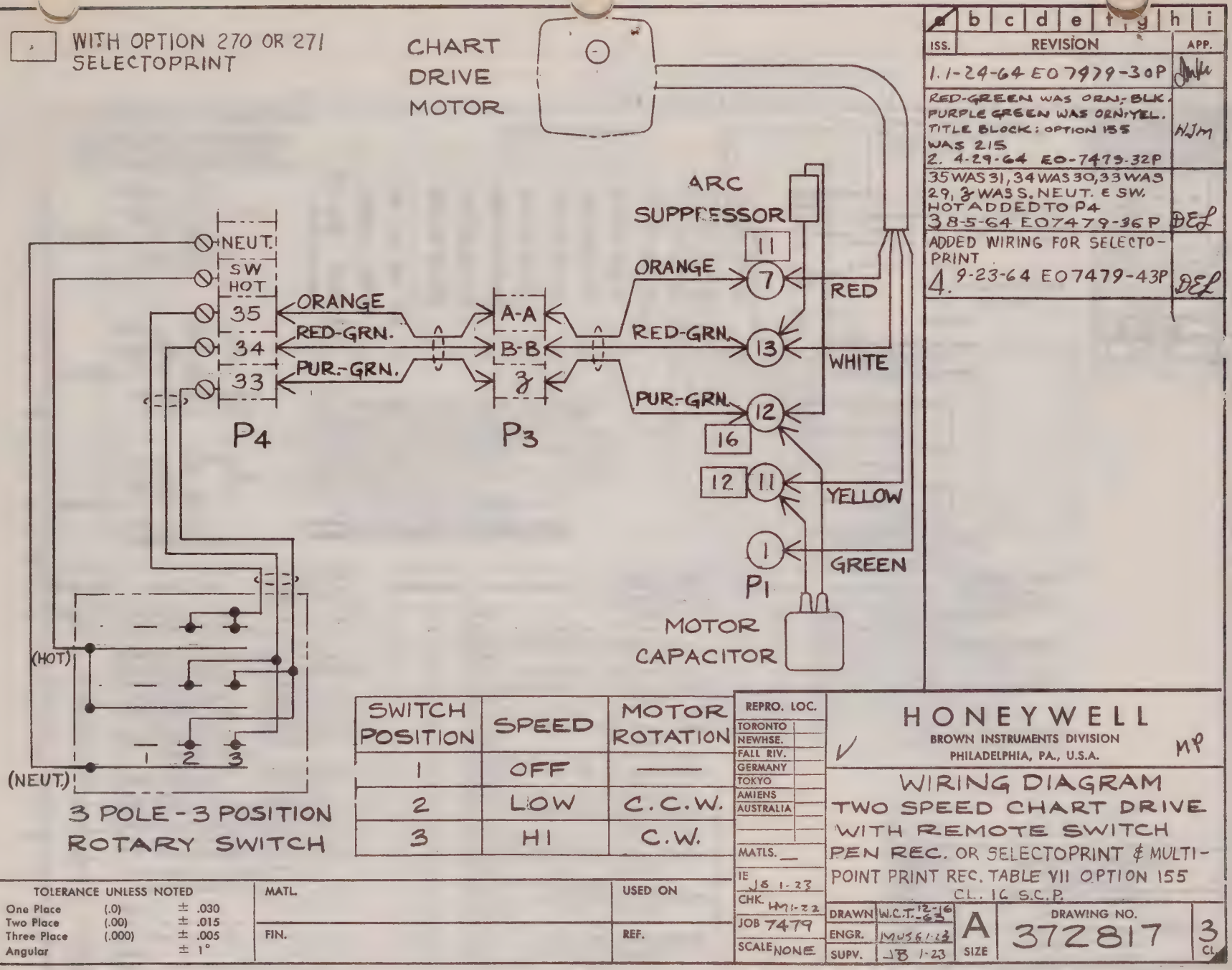
A SIZE — DRAWING NO. 372816 — 3 CL

TOLERANCE UNLESS NOTED		
One Place	(.0)	± .030
Two Place	(.00)	± .015
Three Place	(.000)	± .005
Angular		± 1

MATL. | USED ON
FIN. | REF.

FORM 3201 (REV. 3/63)





SWITCH POSITION	SPEED	MOTOR ROTATION
1	OFF	—
2	LOW	C.C.W.
3	HI	C.W.

ISS.	REVISION	APP.
1.	1-24-64 EO 7979-30P	
	RED-GREEN WAS ORN.-BLK. PURPLE GREEN WAS ORN.-YEL. TITLE BLOCK: OPTION 155 WAS 215 2. 4-29-64 EO-7479-32P	NJM
	35 WAS 31, 34 WAS 30, 33 WAS 29, 3 WAS S. NEUT. & SW. HOT ADDED TO P4 3 8-5-64 EO7479-36P	DEL
	ADDED WIRING FOR SELECTO-PRINT 4. 9-23-64 EO7479-43P	DEL

REPRO. LOC.: TORONTO, NEWHSE., FALL RIV., GERMANY, TOKYO, AMIENS, AUSTRALIA

MATLS. __

IE JB 1-23

CHK. HM 1-22

JOB 7479

SCALE NONE

HONEYWELL
BROWN INSTRUMENTS DIVISION
PHILADELPHIA, PA., U.S.A.

WIRING DIAGRAM
TWO SPEED CHART DRIVE WITH REMOTE SWITCH
PEN REC. OR SELECTOPRINT & MULTI-POINT PRINT REC. TABLE VII OPTION 155
CL. 16 S.C.P.

DRAWN	W.C.T. 12-16-63	
ENGR.	MWS 1-23	
SUPV.	JB 1-23	

A SIZE — DRAWING NO. 372817 — 3 CL.

TOLERANCE UNLESS NOTED		
One Place	(.0)	± .030
Two Place	(.00)	± .015
Three Place	(.000)	± .005
Angular		± 1°

MATL. | USED ON

FIN. | REF.

FORM 3201 (REV. 3/63)

HONEYWELL

WIRING DIAGRAM

TWO SPEED CHART DRIVE

WITH REMOTE START-STOP CONTROL

3 POLE - 3 POSITION

ROTARY SWITCH

SWITCH POSITION	SPEED	MOTOR STATOR
1	SLOW	—
2	HIGH	—
3	HIGH	—

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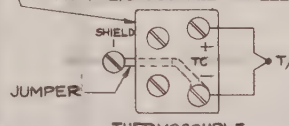
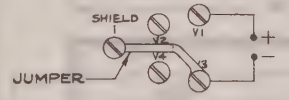
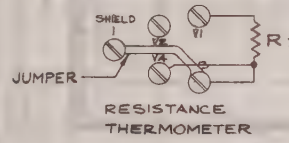
INPUT VARIABLE CONNECTIONS

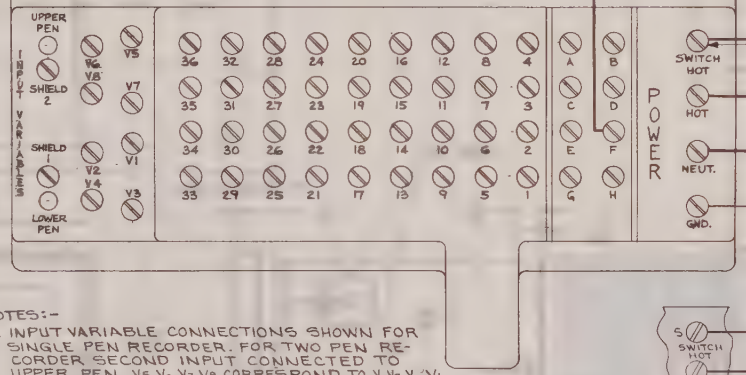
REFERENCE JUNCTION COMPENSATOR (INSTALLED ONLY ON INSTRUMENTS. WITH THERMOCOUPLE PRI. ELEMENT.)

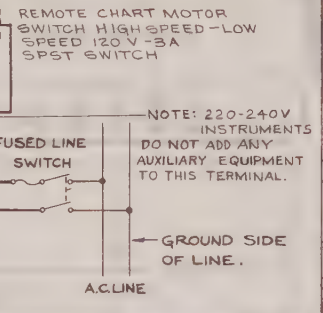






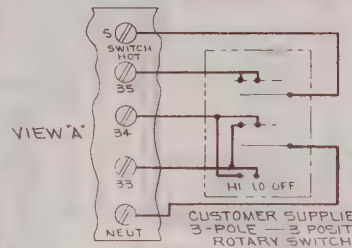
REAR OF INSTRUMENT




REMOTE CHART MOTOR SWITCH HIGH SPEED - LOW SPEED 120 V - 3A SPST SWITCH
NOTE: 220-240V INSTRUMENTS DO NOT ADD ANY AUXILIARY EQUIPMENT TO THIS TERMINAL.
FUSED LINE SWITCH
GROUND SIDE OF LINE.
A.C. LINE
GROUND DIRECTLY AND SEPARATELY TO A SUITABLE GROUND.

NOTES:-

1. INPUT VARIABLE CONNECTIONS SHOWN FOR SINGLE PEN RECORDER. FOR TWO PEN RECORDER SECOND INPUT CONNECTED TO UPPER PEN. V_5, V_6, V_7, V_8 CORRESPOND TO V_1, V_2, V_3, V_4
2. MULTIPOINT INPUTS ON 372829.
3. IN TABLES, OPTIONS USING SAME TERMINALS NOT AVAILABLE TOGETHER.
4. WIRING DIAGRAMS IN TABLE ARE INTERNAL FOR REFERENCE ONLY.
5. SWITCH CONTACTS:
   NO. → FOR PEN ABOVE SET POINT
   N.C. → FOR PEN BELOW SET POINT
6. BEFORE MAKING CONNECTIONS CHECK NAMEPLATE FOR VOLTAGE RATINGS.



DESIGNATION	FUNCTION	MODEL SPEC. OPTION No. WIRING DIAG. No.
SWITCH HOT	NORMALLY HOT WHEN INST. POWER SWITCH ON	STANDARD
F	REMOTE CHART SWITCH FOR LOW OR HIGH SPEED CH. DR.	TABLE VII OPTION 155 W/DIAG 372813 & 372814
A	OPERATION PEN RIGHT HAND	TABLE VII W/DIAG. 372822
B		
C	OPERATION PEN LEFT HAND	TABLE VII W/DIAG. 372822
D		
C	(COM.) THREE WAY OPERATION PEN	TABLE VII
D		
E	LEFT HAND	W/DIAG. 372822
G	PRINT HOLDOUT (MULTIPOINT ONLY)	TABLE VII W/DIAG. 372825
H		
G	PEN LIFTER LOWER (PEN RECORDING ONLY)	TABLE VII W/DIAG. 372825
H		
4	PEN LIFTER UPPER (PEN RECORDING ONLY)	TABLE VII W/DIAG. 372825
8		
33	TWO SPEED CHART DRIVE REMOTE SWITCHING	TABLE VII OPTION 155 W/DIAG. 372817
34		
35		
1	(COM.)	TABLE IV
2	(N.C.) No. 1 SWITCH	OPTION 01XXX
3	(N.O) NON-SELECTIVE	W/DIAG. 372...
5	(COM.)	TABLE IV
6	(N.C.) No. 2 SWITCH	OPTION 01XXX
7	(N.O) NON-SELECTIVE	W/DIAG. 3...

DESIGNATION	FUNCTION	MODEL SPEC. OPTION No. WIRING DIAG. No.
9	(COM.)	TABLE IV
10	(N.C.) No. 3 SWITCH	OPTION 01XXX
11	(N.O) NON-SELECTIVE	W./DIAG. 372156
13	(COM.)	TABLE IV
14	(N.C.) No. 4 SWITCH	OPTION 01XXX
15	(N.O.) NON-SELECTIVE	W./DIAG. 372156
17	(COM.)	TABLE IV
18	(N.C.) NO. 5 SWITCH OR 1ST SWITCH ON UP PEN	OPTION 01XXX
19	(N.O.) NON-SELECTIVE	W./DIAG. 372156
21	(COM.)	TABLE IV
22	(N.C.) NO. 6 SWITCH OR 2ND SWITCH ON UP PEN	OPTION 01XXX
23	(N.O.) NON-SELECTIVE	W./DIAG. 372156
25	(COM.)	TABLE IV
26	(N.C.) NO. 7 SWITCH OR 3RD SWITCH ON UP PEN	OPTION 01XXX
27	(N.O.) NON-SELECTIVE	W./DIAG. 372156
29	(COM.)	TABLE IV
30	(N.C.) NO. 8 SWITCH OR 4TH SWITCH ON UP PEN	OPTION 01XXX
31	(N.O) NON-SELECTIVE	W./DIAG. 372156
12	(0%) 1ST.	TABLE VII
16	(COLLECTOR) TRANSMITTING	
20	(100%) SLIDEWIRE	W./DIAG. 374838
24	(0%) 2ND.	TABLE VII
28	(COLLECTOR) TRANSMITTING	
32	(100%) SLIDEWIRE	W/DIAG. 374838
13	(0%) 3RD TRANSMITTING SLIDEWIRE	TABLE VII
14	(COLLECTOR) TRANS-	
15	(100%)	W/DIAG. 374838

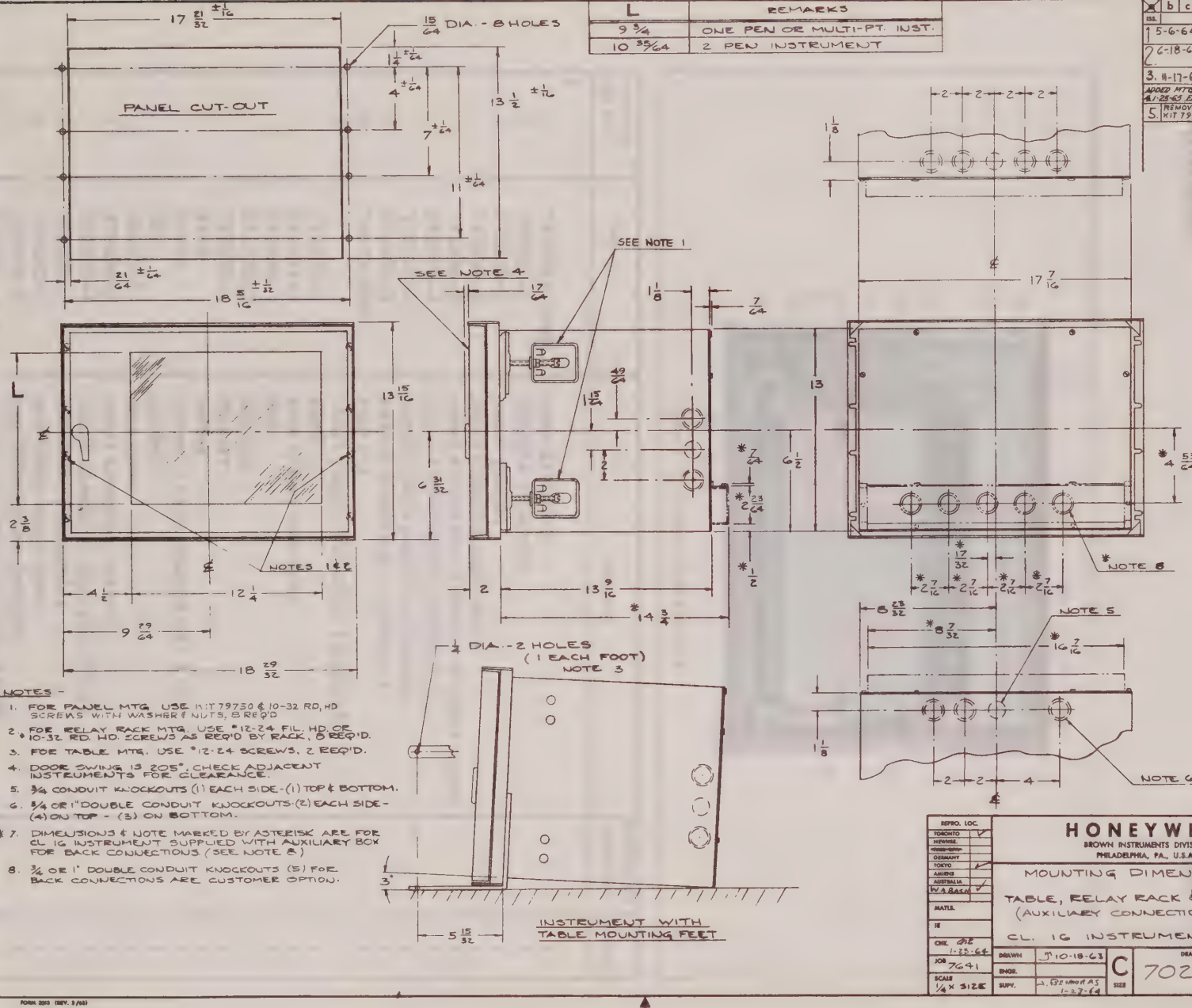
DESIGNATION	FUNCTION		MODEL SPEC. OPTION No. WIRING DIAG. No.
25	(0%) 4TH TRANSMITTING SLIDEWIRE OR		TABLE VII
26	(COLLECTOR) 2ND TRANS-		
27	(100%) MITTING S/W ON UP PEN		W/DIAG. 374838
33	PEN POSITION	REMOTE	TABLE IV
34	SET POINT	PROP.	OPTION 03XX
35	0%	CONTROL	W/D 374838
36	100%		
33	ERROR	REMOTE	TABLE IV
35	0%	PROP	OPTIONS 04XX OR
36	100%	CONTROL	05XX W/D 374838

ISS.	REVISION	APP.	a	b	c	d	e	f	g	h	i
1.	1-24-64 EO 7479-39P	J. Hinkle									
2	E-2) TABLE VII OPTION 155 WAS TABLE VII OPTION 215 2-3-64 EO-7479-32P	Hamm									
3	A-G) ADD REMOTE SW C-5) ADD VIEW "A" ADD. NOTES 1-4 C-1) F "WAS "SWITCH HOT" IN TABLE ADD "NON-SELECTIVE REFS ADD TABLE IV REFS E-1) 35,34 & 33 WERE 29, 30 & 31 D-5) ADD. 33,34,35,36,33 & 35 & 36 8-8-64 EO-7479-36P C-6 & D-3) REV "FUNCTION" COL	Hamm									
4	12-5-64 EO-7479-52P	Hamm									
NOTE 5	NO. WAS NC, NC. WAS NO. 5-19-69	DEP									
6	ADDED NOTE #6 6-30-65	D. C.									
7	374838 WAS 372156 (6) 7-12-65	D. C.									
8	ADDED NOTE AT A-6 11-8-65	DEP									

REPRO. LOC.		HONEYWELL	
TORONTO		BROWN INSTRUMENTS DIVISION	
NEWYBE.		PHILADELPHIA, PA., U.S.A.	
WEST GERMANY			
GERMANY		WIRING DIAGRAM	
TOKYO		(EXTERNAL)	
AMIENS		CUSTOMER TERMINAL PANEL CONNECTIONS	
AUSTRALIA		CL 16 S.C.P.	
MATLS.			
IE JS 1-23			
CHK. HM 1-22			
JOB 7479	DRAWN Thimborn 12-31-1963	DRAWING NO. 372827	
SCALE 3/4 SIZE	ENGR Muse 1-23	SIZE C	
	SUPV J. Bellinger 1-23-64		

L	REMARKS
9 3/4	ONE PEN OR MULTI-PT. INST.
10 35/64	2 PEN INSTRUMENT

ISS.	REVISION	APP.
1	5-6-64 EO7641-9P	DEL
2	6-18-64 EO7641-10P	DEL
3	11-17-64 EO 7641-51P	HS.
	ADDED MTG BRACKET 4/1-25-65 EQ 7641-501R	HS
5	REMOVED NOTE 1, ADDED KIT 79750 9-21-65	



NOTES -

1. FOR PANEL MTG. USE KIT 79750 & 10-32 RD. HD SCREWS WITH WASHER & NUTS, 8 REQ'D
2. FOR RELAY RACK MTG. USE #12-24 FIL. HD. OR 10-32 RD. HD. SCREWS AS REQ'D BY RACK, 8 REQ'D.
3. FOR TABLE MTG. USE #12-24 SCREWS, 2 REQ'D.
4. DOOR SWING IS 205°; CHECK ADJACENT INSTRUMENTS FOR CLEARANCE.
5. 3/4 CONDUIT KNOCKOUTS (1) EACH SIDE - (1) TOP & BOTTOM.
6. 3/4 OR 1" DOUBLE CONDUIT KNOCKOUTS (2) EACH SIDE - (4) ON TOP - (3) ON BOTTOM.
7. * DIMENSIONS & NOTE MARKED BY ASTERISK ARE FOR CL. IG INSTRUMENT SUPPLIED WITH AUXILIARY BOX FOR BACK CONNECTIONS. (SEE NOTE 8.)
8. 3/4 OR 1" DOUBLE CONDUIT KNOCKOUTS (5) FOR BACK CONNECTIONS ARE CUSTOMER OPTION.

REPRO. LOC.	
TORONTO	✓
NEWARK	
GERMANY	
TOKYO	✓
AMERS	
AUSTRALIA	
BY 4 BASIC	✓
MATL.	
HI	
CHK.	1-22-64
JOB	7641
SCALE	1/4 X SIZE

HONEYWELL
BROWN INSTRUMENTS DIVISION
PHILADELPHIA, PA., U.S.A.

MOUNTING DIMENSIONS
TABLE, RELAY RACK & PANEL
(AUXILIARY CONNECTION BOX)
CL. IG INSTRUMENT

DRAWN	10-18-63	C	702814
ENGR.		SIZE	
SUPV.	1-27-64		

DRAWING NO. 3

FORM 2213 (REV. 3/63)

INSTRUMENT

PARTS LIST

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
6				
1	370530-1	chassis assembly		1
2	370507-1	latch assembly		1
3	5-807	screw - 8-32 binding hd. 7/16"		4
4	917	washer		5
5	370514-1	bushing		4
6	370515-1	spring		2
7	723738-1	catch & spring ass'y.		2
8	370877-1	switch ass'y. (power)		1
9	370624-1	switch ass'y. (light)		1
10	370510-1	pin		2
11	77310	nut		2
12	79075-000	ring nut		2
13	8-805	screw - 8-32 fillister hd. 5/16"		1
14	364998	washer		4
15	370503-1	handle assembly		1
16	8-806	screw - 8-32 fillister hd. - 3/8"		1
17	*370400-1	chart module assembly		1
18	*370697-item	servo circuit unit (one pen & multi-point)		1
		servo circuit unit (two pen)		2
19	370885-1	terminal block assembly		1
20	370844-1	R-C unit assembly		1
21	4908	nut		1
22	350962-1	cable clamp		1
23	5-812	screw - 8-32 binding hd. - 3/4"		1
24	370882-1	connector assembly (one pen, two pen & multi-point)		1
	370882-2	connector assembly (two pen)		1
25	370502-2	latch assembly		1
26	370870-1	cover		1
27	5-804	screw - 8-32 binding hd. - 1/4"		3
28	370898-1	capacitor assembly		2
29	5-807	screw - 8-32 binding hd. - 7/16"		1
30	370847-1	wire assembly (ground)		1
31	350962-3	cable clamp		1
32	8-803	screw - 8-32 fillister hd. - 3/16"		1
33	76091	lockwasher		3
34	8-804	screw - 8-32 fillister hd. - 1/4"		2
35	8-404	screw - 4-40 fillister hd. - 1/4"		2
36	370866-1	connector (56 pts.)		1
37	370846-1	capacitor assembly		1
38	370857-1	bracket		2

Figure and Key No	Part No.	Description	Recommended Spare Parts	Quantity
12	370516-1	cover (with lighting - 2 pen - optional)		1
	370516-2	cover (with lighting - 1 pen & multi-point - optional)		1
13	45-range	scale (specify range)		1
14	*370638-1	pen carriage assembly		1
15	370553-1	pen assembly	X	1
16	370502-2	bracket		1
17	*370300-item	operation pen (optional)		1
18	370359-1	chart drum assembly		1
19	*370400-1	chart module assembly		1
20	370394-1	handle assembly		1
21	370626-2	nameplate (power)		1
22	370877-1	switch assembly (power - optional)		1

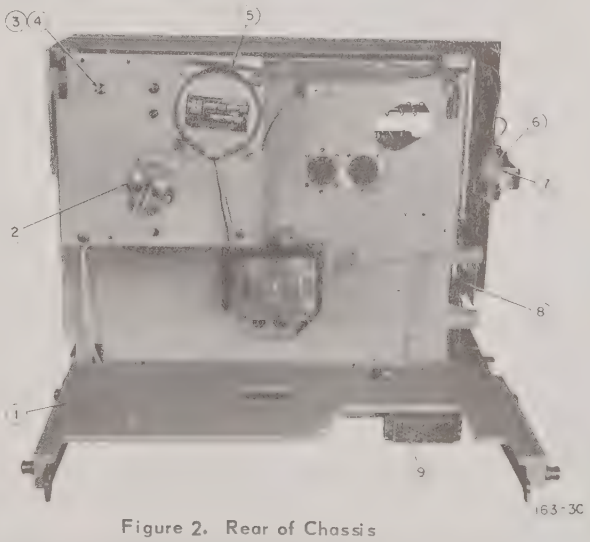


Figure 2. Rear of Chassis

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
2				
1	370530-1	chassis assembly		1
2	*372398-1	servo drive assembly (.2 sec)		1
	*370266-1	servo drive assembly (1/2 & 1 sec.)		1
	*370250-1	servo drive assembly (3,5 & 15 sec.)		1
3	8-805	screw - 8-32 fillister hd. 5/16"		6
4	76091	washer		6
5	687610-502	servo motor (.2 sec.)	X	1
	*365755-503	servo motor (1 sec.)	X	1
	365755-504	servo motor (1/2 sec.)	X	1

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
	*365754-510	servo motor (3, 5 & 15 sec.)	X	1
	365754-511	servo motor (5 & 15 sec.)	X	1
6	365524	ink bottle (operation pen)		1
7	370337-1	bracket		1
8	(see table)	chart drive motor	X	1
9	370866-1	connector		1

CHART DRIVE MOTOR		
120V 60 Cycle	R.P.M.	120V 50 Cycle
370498-1	1/40	370499-1
-2	1/20	-2
-3	3/20	-3
-4	1/4	-4
-5	3/10	-5
-6	1/2	-6
-7	3/4	-7
-8	1-1/2	-8

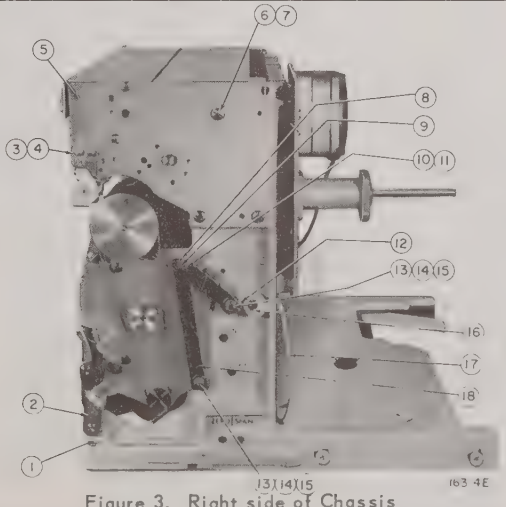


Figure 3. Right side of Chassis

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
3				
1	370530-1	chassis assembly		1
2	370394-1	handle assembly		1
3	5-603	screw - 6-32 binding hd. 3/16"		2
4	78196	lockwasher		2
5	370562-1	plate		1
6	8-805	screw - 8-32 fillister hd. 5/16"		3
7	76091	washer		3
8	370398-2	stop link		1
9	370484-1	stud		1
10	9748	cotter		1
11	4971	washer		1
12	370486-1	spring		1
13	5-806	screw - 8-32 binding hd. 3/8"		2
14	299	washer		2
15	370399-1	spacer		2
16	370835-1	screw (amplifier mount)		1
17	370882-1	connector assembly		1
18	370398-1	stop link		1

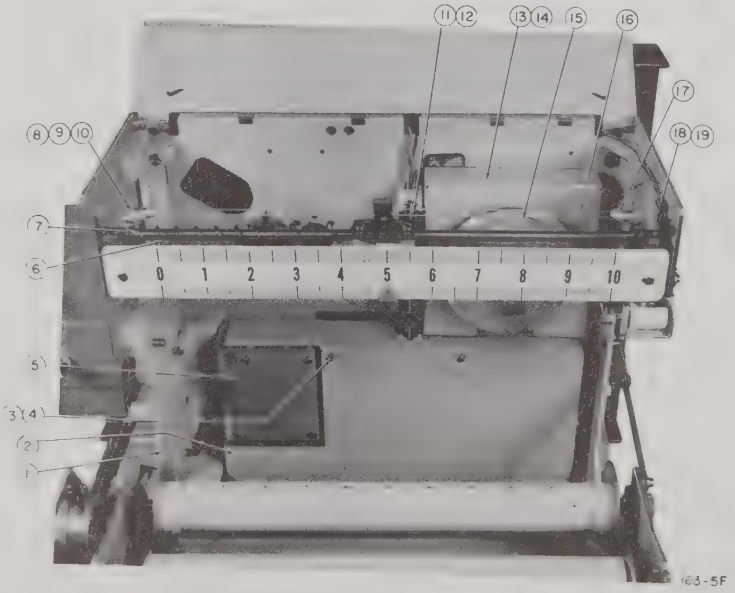


Figure 4. Components – Front of Chassis

INSTRUMENT **PARTS LIST**

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
4				
1	370530-1	chassis assembly		1
2	370744-1	cover		1
	370744-2	cover (used with checking terminal option)		1
3	372919-1	screw		2
4	78196	washer		2
5	*370698-item	amplifier assembly	X	1
6	370582-1	tubing	X	1
7	370574-1	shaft		1
8	370558-2	pulley & bracket ass'y.		1
9	8-803	screw - 8-32 fillister hd. 3/16"		2
10	76091	washer		2
11	370887-1	terminal block ass'y.		1
12	370856-1	cover (terminal panel)		1
13	*370801-item	service replacement slidewire ass'y.	X	1
14	370816-1	cover for slidewire		1
15	370804-2	pulley assembly		1
16	370292-1	drive cable	X	1
17	370558-1	pulley & bracket ass'y.		1
18	350962-4	cable clamp		1
19	5-804	screw - 8-32 binding hd. 1/4"		1

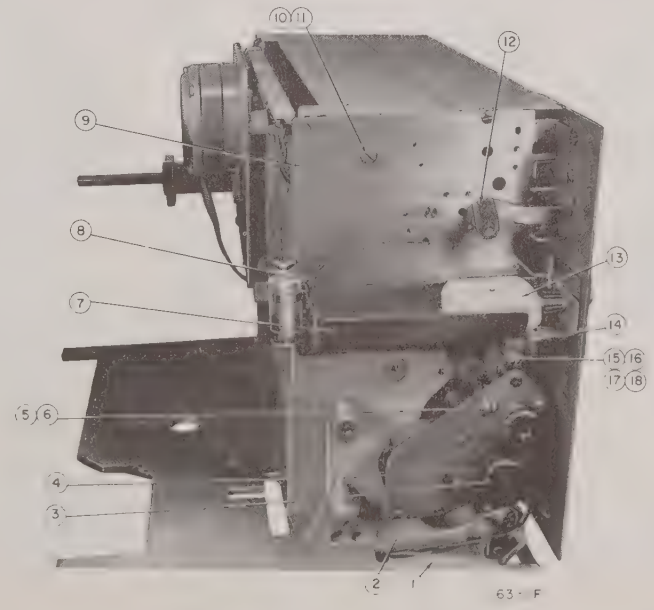


Figure 5. Left side of Chassis

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
5				
1	370530-1	chassis assembly		1
2	*370380-1	chart drive assembly (low speed)		1
3	723246-1	knob		2
4	370110-1	change gear (40T - optional)		1
5	5-832	screw - 8-32 binding hd. 2"		3
6	9771	lockwasher		3
7	370639-1	ink drawer assembly		1
8	370582-1	tubing	X	1
9	370563-1	plate		1
10	5-805	screw - 8-32 binding hd. 5/16"		3
11	9771	lockwasher		3
12	372207-1	hub assembly		1
13	370621-1	bottle assembly		1
14	370604-1	brace plate		1
15	5-603	screw - 6-32 binding hd. 3/16"		1
16	78196	lockwasher		1
17	370603-1	stud brace		1
18	299	washer		1

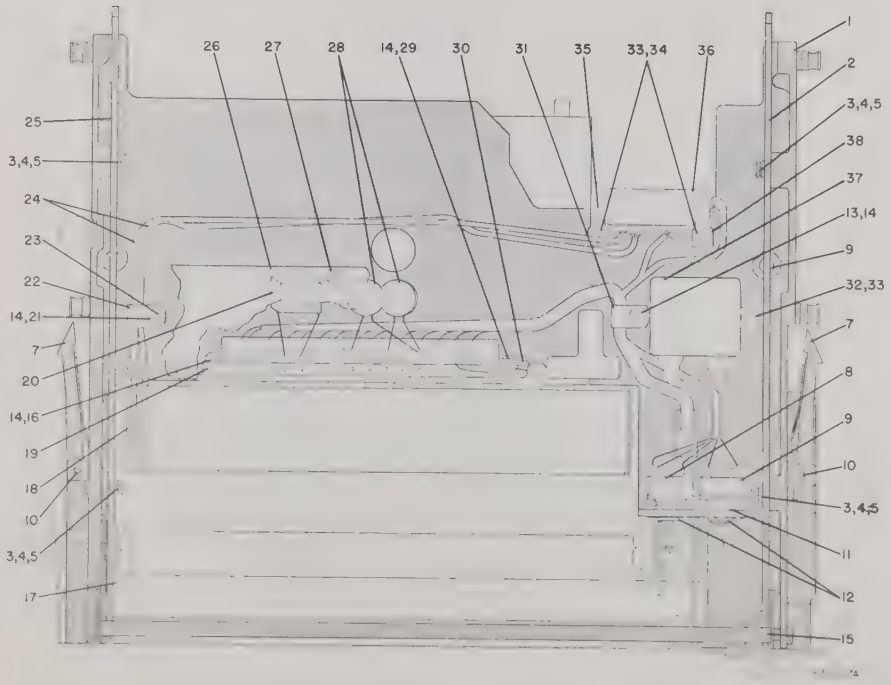


Figure 6. Bottom of Chassis

INSTRUMENT

PARTS LIST

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
6				
1	370530-1	chassis assembly		1
2	370507-1	latch assembly		1
3	5-807	screw - 8-32 binding hd. 7/16"		4
4	917	washer		5
5	370514-1	bushing		4
6	370515-1	spring		2
7	723738-1	catch & spring ass'y.		2
8	370877-1	switch ass'y. (power)		1
9	370624-1	switch ass'y. (light)		1
10	370510-1	pin		2
11	77310	nut		2
12	79075-000	ring nut		2
13	8-805	screw - 8-32 fillister hd. 5/16"		1
14	364998	washer		4
15	370503-1	handle assembly		1
16	8-806	screw - 8-32 fillister hd. - 3/8"		1
17	*370400-1	chart module assembly		1
18	*370697-item	servo circuit unit (one pen & multi-point)		1
		servo circuit unit (two pen)		2
19	370885-1	terminal block assembly		1
20	370844-1	R-C unit assembly		1
21	4908	nut		1
22	350962-1	cable clamp		1
23	5-812	screw - 8-32 binding hd. - 3/4"		1
24	370882-1	connector assembly (one pen, two pen & multi-point)		1
	370882-2	connector assembly (two pen)		1
25	370502-2	latch assembly		1
26	370870-1	cover		1
27	5-804	screw - 8-32 binding hd. - 1/4"		3
28	370898-1	capacitor assembly		2
29	5-807	screw - 8-32 binding hd. - 7/16"		1
30	370847-1	wire assembly (ground)		1
31	350962-3	cable clamp		1
32	8-803	screw - 8-32 fillister hd. - 3/16"		1
33	76091	lockwasher		3
34	8-804	screw - 8-32 fillister hd. - 1/4"		2
35	8-404	screw - 4-40 fillister hd. - 1/4"		2
36	370866-1	connector (56 pts.)		1
37	370846-1	capacitor assembly		1
38	370857-1	bracket		2

DOOR ASSEMBLY

PARTS LIST

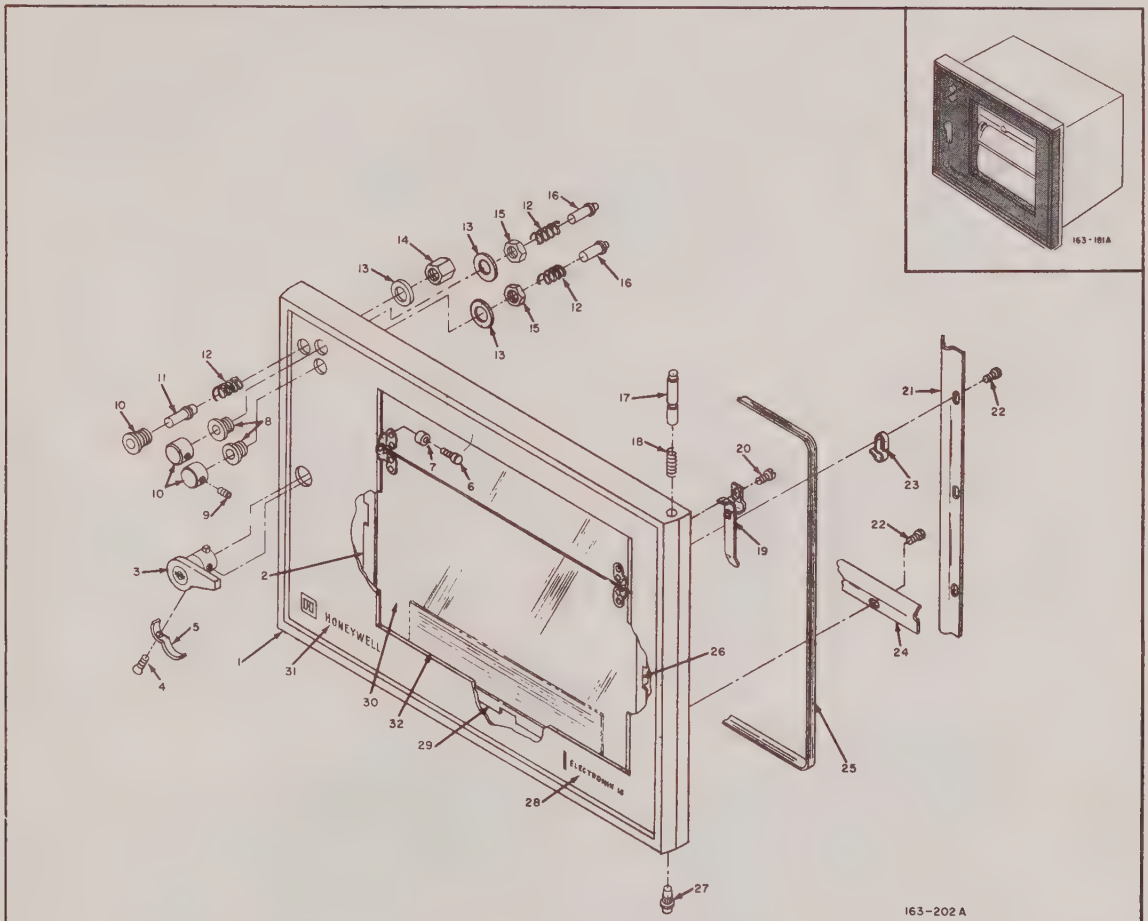


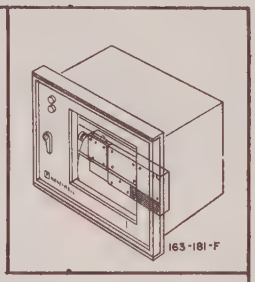
Figure 1. Door Assembly

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
1		door assembly - specify model and serial number of instrument		
1	370651-1	door (multipoint or 1 pen - color dark beige)		1
	370651-2	door (multipoint or 1 pen - specify color)		1
	370651-3	door (2-pen - color dark beige)		1
	370651-4	door (2-pen - specify color)		1
2	370691-2	gasket		1
3	370689-1	latch with lock (optional - color dark beige)		1
	370689-2	latch with lock (optional - specify color)		1

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
	370690-1	latch without lock (color dark beige)		1
	370690-2	latch without lock (specify color)		1
4	7-203	screw - 2-56 flat hd. 3/16"		1
5	370692-1	clip - spring		1
6	8-205	screw - 2-56 fillister hd. 5/16"		1
7	370688-1	stop		1
8	370678-1	knob		2
9	40958-2	setscrew		2
10	370679-1	bushing		3
11	372884-1	plunger		1
12	74253	spring		3
13	370680-1	washer		3
14	372883-1	housing		1
15	370677-1	nut		2
16	74257-3	shaft		2
17	370668-1	pin - door		1
18	79034	spring		1
19	370655-1	lever ass'y.		
20	5-604	screw - 6-32 binding hd. 1/4"		1
21	370662-1	strip - retaining		3
22	24-804	screw - 8-32 hex hd. 1/4"		9
23	372983-1	clip r.h. (used on split glass option)		1
	372983-2	clip l.h. (used on split glass option)		1
24	372995-1	strip - retaining (used on split glass option)		1
25	370667-1	gasket		1
26	370691-1	gasket		1
27	723693-2	pin - door		1
28	370659-1	decal comania		1
29	370691-3	gasket		1
30	370670-1	glass (double thick - optional)		1
	370670-2	glass (plexi-glass-optional)		1
	370670-3	glass (safety-glass-optional)		1
	372991-1	glass ass'y. (split-glass door - optional)		1
31	370658-1	decal comania		1
32	370663-1	auxiliary nameplate (optional - specify exact wording)		1

MEASURING CIRCUIT

PARTS LIST



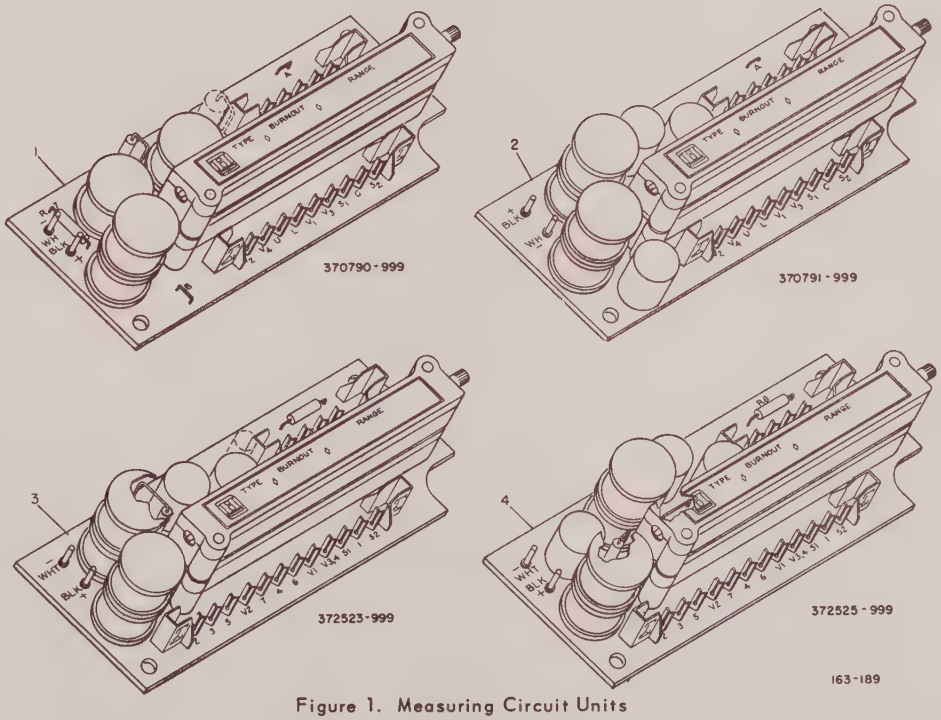


Figure 1. Measuring Circuit Units

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
1				
1	370790-999	measuring circuit ass'y. - for T.C., M.V., D.C. volt, tachometer, D.C. current and radiomatic actuations		1
2	370791-999	measuring circuit ass'y. - for resistance thermometer		1
3	372523-999	measuring circuit ass'y. - for millivolt, thermocouple, D.C. volt, D.C. current, radiomatics, up & down scale burnouts & tachometer (stranducer)		1
4	372525-999	measuring circuit ass'y. - resistance thermometer (stranducer)		1

INDICATING COMPONENT

PARTS LIST

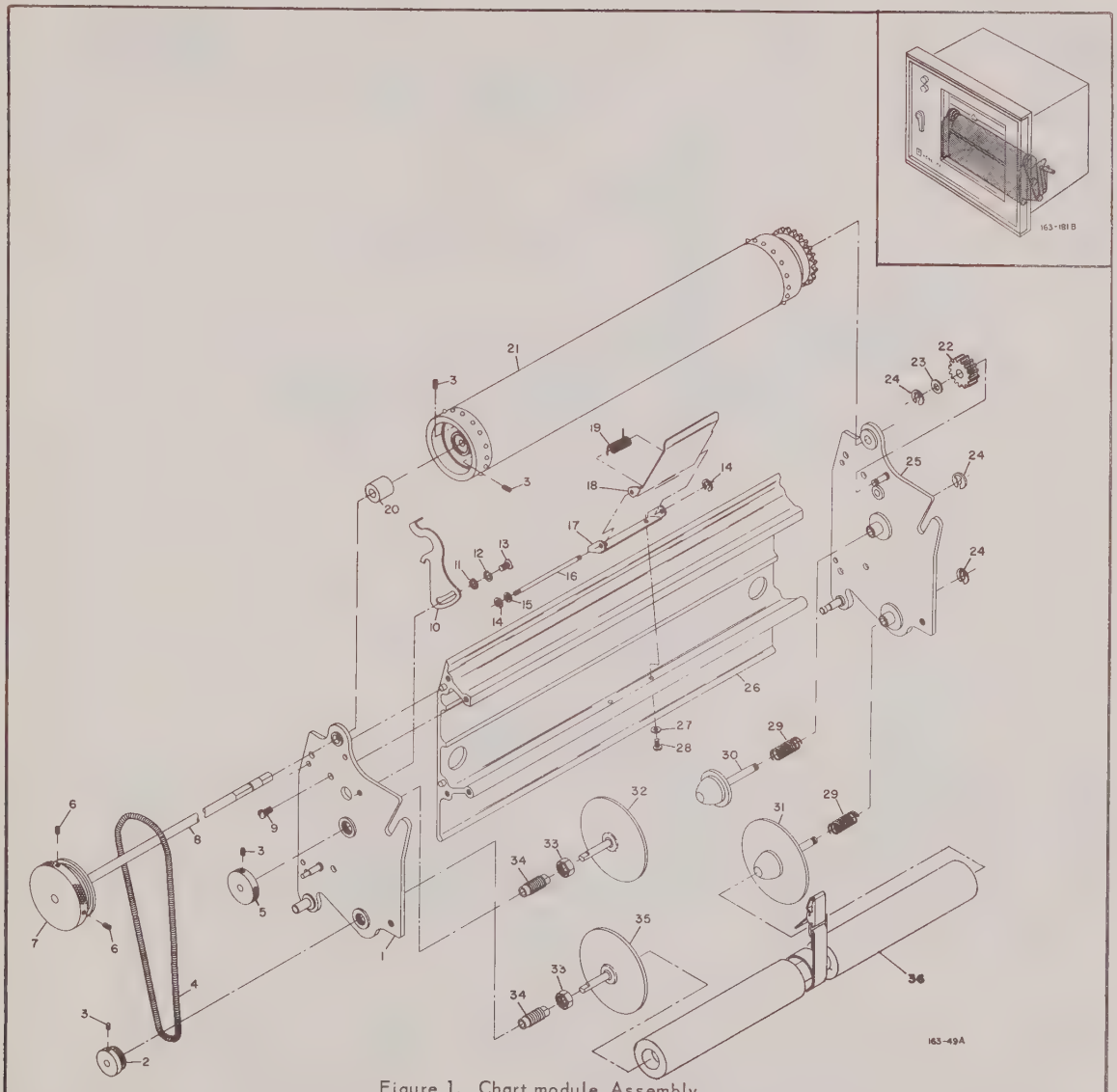


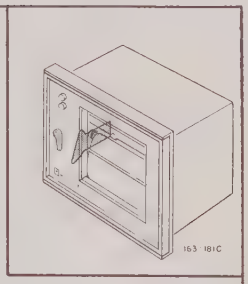
Figure 1. Chart module Assembly

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
1	370400-1	chart module assembly		1
1	370350-1	side plate assembly - r.h.		1
2	372587-1	pulley knob		1
3	40958-3	setscrew		4
4	370374-1	spring	X	1
5	370438-1	knob		1
6	40958-2	setscrew		2
7	370364-1	knob		1
8	370455-1	shaft		1

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
9	5-806	screw - 8-32 binding hd. 3/8"		8
10	370379-1	pointer		1
11	364998	washer		1
12	917	lockwasher		1
13	8-804	screw - 8-32 fillister hd. 1/4"		1
14	79208	cotter		2
15	6885	washer		2
16	370378-1	shaft		1
17	370376-1	bracket		1
18	370375-1	plate		1
19	370377-1	spring		1
20	370363-1	spacer		1
21	370359-1	chart drum assembly		1
22	370365-1	idler gear (38T)		1
23	77249	washer		1
24	9748	cotter		3
25	370355-1	side plate assembly - l.h.		1
26	370408-1	chart plate		1
27	78196	lockwasher		2
28	5-604	screw - 6-32 binding hd. 1/4"		2
29	370445-1	spring		2
30	370431-2	supply holder assembly		1
31	370431-1	reroll holder assembly		1
32	372580-1	supply center assembly		1
33	75882	locknut		2
34	372588-1	bearing		2
35	372580-2	reroll center assembly		1
36	355556	chart saver reroll ass'y. (optional)		1

INDICATING COMPONENTS

PARTS LIST



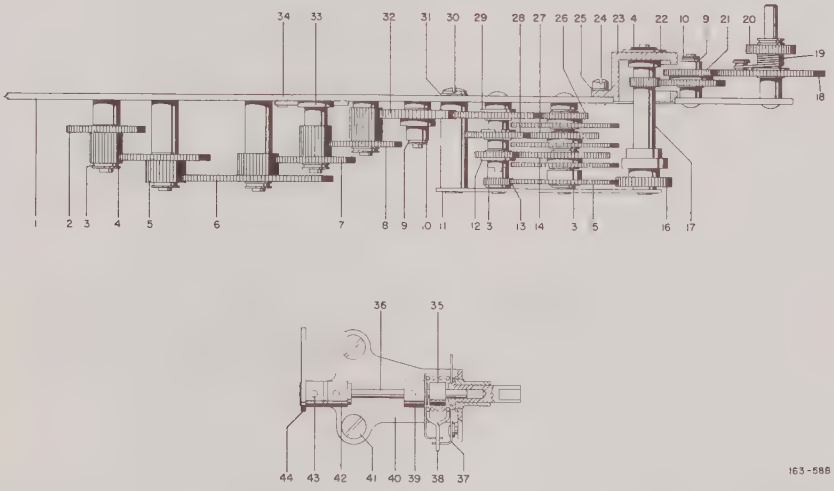


Figure 1. 4 Speed chart drive.

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
		4 speed chart drive assembly (see table 1) Component Parts for Above Assembly (see Table 2)		1

TABLE 1
4 SPEED CHART DRIVE

PART NUMBER	BASIC CHART SPEED FOR 60 CYCLE INSTRUMENTS MOTOR SPEED RPM			
	30	60	90	180
370900-1	1" min	2" min	-	6" min
370900-2	1" hr	2" hr	-	6" hr
370901-1	-	-	-	12" min
370901-2	-	-	-	12" hr
370901-3	1-1/2" min.	-	-	-
370902-1	10" min	20" min	30" min	-
370902-2	10" hr	20" hr	30" hr	-
370902-3	7-1/2" hr.	15" hr	22-1/2" hr	-

TABLE 2

Key No.	Part Number	DESCRIPTION	USED ON							
			370900-1	370900-2	370901-1	370901-2	370901-3	370902-1	370902-2	370902-3
1	370903-1	gear plate assembly	1	-	-	-	-	-	-	-
1	370903-2	gear plate assembly	-	-	1	-	1	-	-	-
1	370903-3	gear plate assembly	-	-	-	-	-	1	-	-
1	370903-4	gear plate assembly	-	1	-	-	-	-	-	-
1	370903-5	gear plate assembly	-	-	-	1	-	-	-	-
1	370903-6	gear plate assembly	-	-	-	-	-	-	1	1
2	370911-1	gear assembly (20 & 52T)	-	1	-	1	-	-	1	1
3	77249	washer	4	8	4	8	4	3	7	7
4	9748	cotter	3	7	3	7	3	2	6	6
5	370914-1	gear assembly (26 & 60T)	-	1	-	1	-	-	1	1
6	370914-2	gear assembly (26 & 100T)	-	1	-	1	-	-	1	1
7	370911-2	gear assembly (20 & 52T)	-	1	-	1	-	-	1	1
8	370919-1	gear assembly (20 & 48T)	1	1	1	1	1	-	-	-
8	370921-2	idler assembly (52T)	-	-	-	-	-	1	1	1
9	42081	washer	2	2	2	2	2	3	3	3
10	7403	cotter	2	2	2	2	2	3	3	3
11	370943-1	gear stabilizing plate	1	1	1	1	1	1	1	1
12	370926-1	gear assembly (30T)	1	1	1	1	1	1	1	1
13	370929-1	gear assembly (18T)	1	1	1	1	1	1	1	1
14	370930-3	gear assembly (72 & 60T)	1	1	1	1	1	1	1	1
15	370932-1	gear assembly (72T)	1	1	1	1	1	1	1	1
16	370999-1	shift gear (36T)	1	1	1	1	1	1	1	1
17	372552-1	gear assembly (18T)	1	1	-	-	-	-	-	-
17	372552-2	gear assembly (30T)	-	-	1	1	1	1	1	1
18	372954-1	gear assembly (72T)	1	1	1	1	-	1	1	-
18	372954-4	gear assembly (80T)	-	-	-	-	1	-	-	1
19	372959-1	spring	1	1	1	1	1	1	1	1
20	372951-1	gear assembly (20T)	1	1	1	1	1	1	1	1
21	370938-1	gear assembly (36 & 45T)	1	1	-	-	-	-	-	-
21	370964-1	gear assembly (48 & 50T)	-	-	1	1	-	1	1	-
21	370964-2	gear assembly (40 & 50T)	-	-	-	-	1	-	-	1
22	370997-1	washer	1	1	1	1	1	1	1	1
23	370934-1	bearing support assembly	1	1	1	1	1	1	1	1
24	8-604	screw — 6-32 fil. hd.	3	3	3	3	3	3	3	3
25	73644	lockwasher	3	3	3	3	3	3	3	3
26	370930-1	gear assembly (72 & 30T)	1	1	1	1	1	1	1	1
27	370930-2	gear assembly (72 & 45T)	1	1	1	1	1	1	1	1
28	370924-2	gear assembly (45T)	1	1	1	1	1	1	1	1
29	370924-1	gear assembly (60T)	1	1	1	1	1	1	1	1
30	5-806	screw — 8-32 binding hd.	3	3	3	3	3	3	3	3
30	9771	lockwasher	3	3	3	3	3	3	3	3
31	370921-1	gear assembly (50T)	1	1	1	1	1	-	-	-
32	370973-1	gear assembly (50T & 24T)	-	-	-	-	-	1	1	1
33	370916-1	stud assembly	-	1	-	1	-	-	1	1
34	7-603	screw — 6-32 flat hd.	-	2	-	2	-	-	2	2
35	370957-1	spacer	1	1	1	1	1	1	1	1
36	370953-1	shaft	1	1	1	1	1	1	1	1
37	370956-1	lever assembly	1	1	1	1	1	1	1	1
38	370954-1	spring	1	1	1	1	1	1	1	1
39	370967-1	lever assembly	1	1	1	1	1	1	1	1
40	370948-1	bracket assembly	1	1	1	1	1	1	1	1
41	5-003	screw — 10-32 binding hd.	2	2	2	2	2	2	2	2
42	369937-1	hub	1	1	1	1	1	1	1	1
43	40958-2	setscrew	3	3	3	3	3	3	3	3
44	370949-1	shift lever assembly	1	1	1	1	1	1	1	1

INDICATING COMPONENTS

PARTS LIST

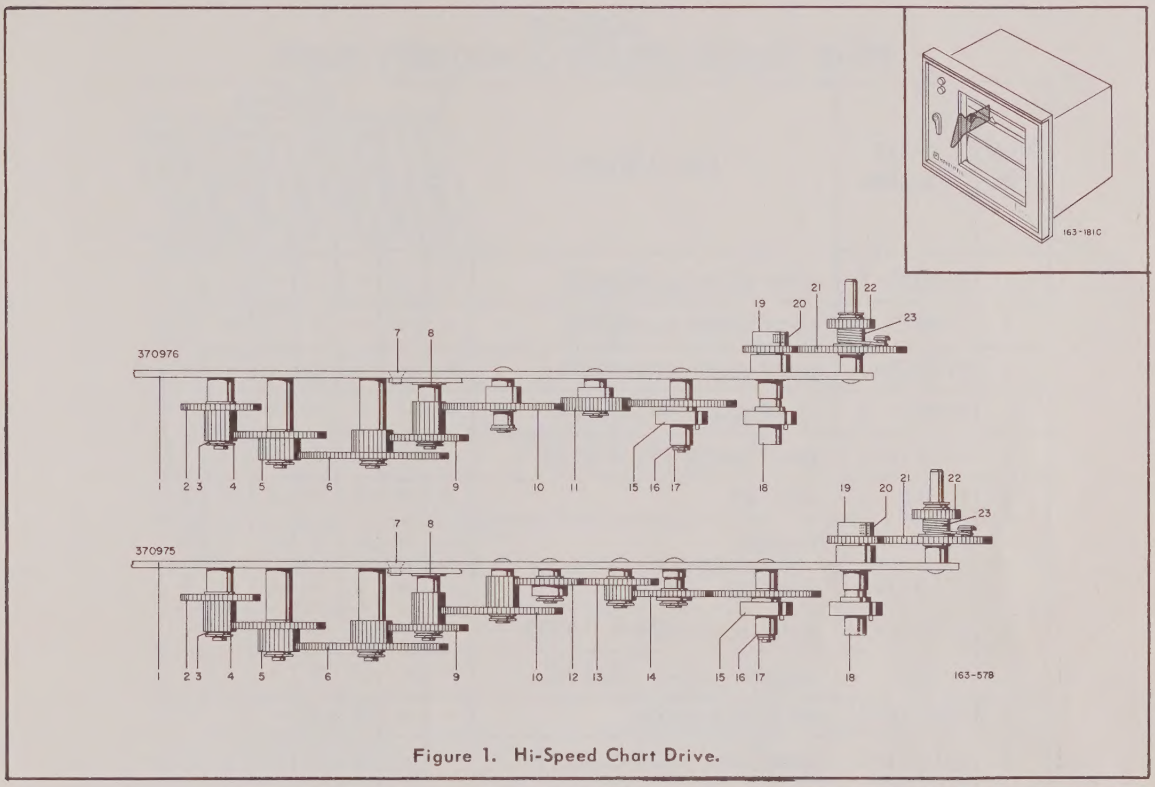


Figure 1. Hi-Speed Chart Drive.

Figure and Key No.	Part No.	Description	Recommended Spare Parts	Quantity
		hi-speed chart drive assembly (see Table 1) component parts for above assembly (see Table 2)		1

TABLE 1
HI-SPEED CHART DRIVE ASSEMBLY

PART NUMBER	BASIC CHART SPEED FOR 60-CYCLE INSTRUMENTS MOTOR SPEED RPM			
	30	60	90	180
370975-1	1" min	2" min	-	6" min
370975-2	-	-	-	12" min
370975-3	1" hr	2" hr	-	6" hr
370975-4	-	-	-	12" hr
370976-1	10" min	20" min	30" min	60" min
370976-2	-	-	-	120" min
370976-3	10" hr	20" hr	30" hr	-

TABLE 2
GEAR ASSEMBLIES AND COMPONENT PARTS

Key No.	Part Number	Description	Used on						
			370975-1	370975-2	370975-3	370975-4	370976-1	370976-2	370976-3
1	370977-1	gear plate assembly	1	1	-	-	-	-	-
1	370977-2	gear plate assembly	-	-	-	-	1	1	-
1	370977-3	gear plate assembly	-	-	1	1	-	-	-
1	370977-4	gear plate assembly	-	-	-	-	-	-	1
2	370911-1	gear ass'y (20 & 52T)	-	-	1	1	-	-	1
3	77249	washer	5	5	9	9	3	3	7
4	9748	cotter	5	5	9	9	3	3	7
5	370914-1	gear ass'y (26 & 60T)	-	-	1	1	-	-	1
6	370914-2	gear ass'y (26 & 100T)	-	-	1	1	-	-	1
7	7-603	screw — 6-32 flat hd.	-	-	2	2	-	-	2
8	370916-1	stud assembly	-	-	1	1	-	-	1
9	370911-2	gear ass'y (20 & 52T)	-	-	1	1	-	-	1
10	370980-1	gear ass'y (20 & 80T)	1	1	1	1	-	-	-
10	370988-2	gear ass'y (80T)	-	-	-	-	1	1	1
11	370993-1	gear ass'y (44T)	-	-	-	-	1	1	1
12	370982-1	gear ass'y (44T)	1	1	1	1	-	-	-
13	370986-1	gear ass'y (20 & 50T)	1	1	1	1	-	-	-
14	370988-1	gear ass'y (52T)	1	1	1	1	-	-	-
15	370084-4	gear ass'y (72T)	1	1	1	1	1	1	1
16	42081	washer	1	1	1	1	1	1	1
17	7403	cotter	1	1	1	1	1	1	1
18	370991-1	hub & shaft assembly	1	1	1	1	1	1	1
19	370371-3	gear ass'y (54T)	-	1	-	1	-	1	-
19	370371-2	gear ass'y (36T)	1	-	1	-	1	-	1
20	40958-1	setscrew	1	1	1	1	1	1	1
21	372954-1	gear ass'y (72T)	1	-	1	-	1	-	1
21	372954-3	gear ass'y (54T)	-	1	-	1	-	1	-
22	372951-1	gear ass'y. (20T)	1	1	1	1	1	1	1
23	372959-1	spring	1	1	1	1	1	1	1

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